Oregon Agricultural College

Experiment Station

Director's Biennial Report 1920-1922

AUGUST, 1922

CORVALLIS, OREGON

The regular bulletins of the Station are sent free to the residents of Oregon who request them.

BOARD OF REGENTS OF THE OREGON AGRICULTURAL COLLEGE AND EXPERIMENT STATION

Hon. J. K. Weatherford, President	Albany
Hon. N. R. Moore, Secretary	Corvallis
Hon. B. F. Irvine, Treasurer	Portland
Hon. Ben W. Olcott, Governor	Salem
Hon. Sam A. Kozer, Secretary of State	Salem
Hon. J. A. Churchill, Superintendent of Public Instruction	Salem
Hon. Charles E. Spence, Master of State Grange	Oregon City
Hon. C. L. Hawley	Portland
Hon. Walter M. Pierce	LaGrande
Hon. Harry Bailey	Lakeview
Hon. Geo. M. Cornwall	Portland
Hon. Jefferson Myers	Portland
Hon. M. S. Woodcock	Corvallis

STATION STAFF

W. J. Kerr, D.Sc., LL.D.	President
J. T. Jardine, B.Sc.	Director
E. T. Reed, B.Sc., A.B.	Editor
H. P. Barss, A.B., S.M.	Plant Pathologist
P. M. Brandt, B.Sc., A.M.	Dairy Husbandman
A. G. Bouquet, B.Sc.	Horticulturist (Vegetable Gardening)
G. G. Brown, B.Sc.	Horticulturist, Hood River Br. Exp. Station, Hood River
W. S. Brown, A.B., M.S.	Horticulturist in Charge
D. E. Bullis, B.Sc.	Assistant Chemist
Leroy Childs, A.B.	Supt. Hood River Branch Exp. Station, Hood River
G. V. Copson, M.S.	Bacteriologist
H. K. Dean, B.Sc.	Supt. Umatilla Branch Exp. Station, Hermiston
A. E. Engbretson, B.Sc.	Supt. John Jacob Astor Br. Exp. Station, Astoria
B. B. Fulton, B.A., M.S.	Associate Entomologist
W. V. Halversen, M.S.	Assistant Bacteriologist
E. M. Harvey, Ph.D.	Horticulturist (Physiology)
G. R. Hyslop, B.Sc.	Farm Crop Specialist
W. W. Johnston, B.Sc.	Assistant in Soils (Irrigation)
J. S. Jones, M.S.	Chemist
R. C. Jones, B.Sc.	Associate Dairy Husbandman
F. L. Knowlton, B.Sc.	Assistant Poultry Husbandman
J. C. Lewis	Farm Crop Foreman
A. L. Lovett, B.Sc.	Entomologist
A. G. Lunn, B.Sc.	Poultry Husbandman in Charge
F. W. Miller, M.S., D.V.M.	Assistant Veterinarian
H. G. Miller, M.S.	Associate Chemist
G. A. Mitchell, B.Sc.	Asst. to Supt. of Sherman County Branch Station
M. B. McKay, M.S.	Associate Plant Pathologist
O. M. Nelson, B.Sc.	Associate Animal Husbandman
J. R. Nevius, B.Sc.	Assistant Farm Crop Specialist
A. W. Oliver, B.Sc.	Assistant Animal Husbandman
E. L. Potter, M. S.	Animal Husbandman
W. L. Powers, M.S.	Chief, Department of Soils
F. C. Reimer, M.S.	Supt. Southern Oregon Br. Exp. Station, Talent
R. H. Robinson, M.S.	Associate Chemist
C. C. Ruth, M.S.	Assistant Farm Crop Specialist
C. V. Ruzek, B.Sc.	Associate in Soils (Fertility)
Bertha M. Hite	Scientific Asst. Seed Lab. U. S. Dept. of Agri. (Seed Analyst)
H. A. Schoth, M.S.	Scientific Asst. in Forage Crops, U. S. Dept. of Agri.
C. E. Schuster, M.S.	Assistant Horticulturist (Pomology)
H. D. Scudder, B.Sc.	Chief in Farm Management
O. Shattuck, M.S.	Supt. Harney County Branch Exp. Station, Burns
B. T. Simms, B.Sc., D.V.M.	Veterinarian
D. E. Stephens, B.Sc.	Supt. Sherman County Br. Exp. Station, Moro
E. F. Torgerson, B.Sc.	Assistant in Soils (Soils Survey)
E. H. Wiegand, B.Sc.	Horticulturist (Horticultural Products)
Robert Withycombe, B.Sc.	Supt. Eastern Oregon Br. Exp. Station, Union
H. M. Woolman, Field Asst., Office of Cereal Investigations, U. S. Dept. of Agri.	
Willard W. Yates, B.Sc.	Assistant Chemist
S. M. Zeller, Ph.D.	Associate Plant Pathologist

CONTENTS

	Pages
INTRODUCTION	5
COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE	6
OUTSTANDING STATION ACCOMPLISHMENTS OF THE BIENNIUM	6-8
STATION IS UNABLE TO MEET THE DEMAND FOR INVESTIGATIONS	9-10
OTHER UNSOLVED PROBLEMS OF EQUAL OR GREATER IMPORTANCE	10-13
MISCELLANEOUS SERVICE	14
IMPORTANT NEEDS OF THE STATION	14-16
PUBLICATIONS	16-30
RESULTS OF INVESTIGATIONS UNDER WAY	30-104
Department of Animal Husbandry	30-32
Department of Dairy Husbandry	32-35
Department of Poultry Husbandry	35-38
Department of Veterinary Medicine	38-42
Department of Farm Crops	42-49
Department of Soils	49-57
Department of Agricultural Chemistry	57-59
Department of Bacteriology	59-63
Department of Zoology	63-64
Department of Farm Management	64-66
Department of Horticulture	66-72
Department of Botany and Plant Pathology	72-75
Department of Entomology	75-79
Branch Experiment Stations	79-104
John Jacob Astor Branch Station	79-81
Harney Valley Branch Station	81-83
Umatilla Branch Station	83-87
Hood River Branch Station	87-91
Moro Branch Station	91-95
Southern Oregon Branch Station	95-101
Eastern Oregon Branch Station	101-104

August 2, 1922

TO THE PRESIDENT OF THE COLLEGE

Sir:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Oregon Agricultural College for the biennium ended June 30, 1922. It includes a brief account of the work and results during the two years, and again directs attention to urgent needs of the Station.

J. T. JARDINE,
Director.

Director's Biennial Report

OREGON AGRICULTURAL EXPERIMENT STATION

1920-1922

August, 1922

INTRODUCTION

The purpose of this report is to discuss briefly the work of the Agricultural Experiment Station for the two years ending June 30, 1922 and direct attention to some of the important unsolved problems of agriculture in Oregon and to some of the problems and needs of the Station if it is to make the progress and get the results expected by people of the state.

In the report for the biennium ended June 30, 1920, mention was made of "increased demand for the aid of Station staff members on other than investigational work." Attention is directed to the brief special discussion of Service, and comments in the Department statements of this report. The time devoted to other than experimental and research work is without doubt of far reaching benefit. There is the fact, however, that such service does not solve the ever coming new problems of agriculture but merely assists in applying solutions for old problems already worked out by the Station. The interests of the state and the individual farmers warrant earnest cooperative effort of the public and divisions of the College to the end that the Experiment Station Staff are not forced by popular demand to slight their primary function—study and experimentation to solve unsolved problems and unanswered questions in the agriculture of Oregon—in order to tell over and over the solution of problems solved.

The progress of the Experiment Station work is indicated by the short statements of findings published in bulletins, circulars and technical articles, and the brief reports by Departments upon the many investigations under way. Special mention is made of a few station findings which were developed during the biennium to outstanding value in the agriculture of the state.

As a whole a very great amount of work has been done and progress has been excellent, due in no small part to the most hearty cooperation, enthusiasm, and untiring efforts of the station staff members. It would be beyond hope, however, that all problems could be investigated which merit or in some cases almost necessitate study. To give an idea of the situation in this respect some of the requests for experimental work which could not be done due to lack of funds and to problems which merit study, are mentioned.

Attention is directed also to difficulty of meeting demands for publications without devoting an unwarranted proportion of station funds to this purpose.

COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE

The United States Department of Agriculture continued valuable cooperation in several important investigations, and cooperation in new lines was undertaken. Of the Federal Bureau of Plant Industry the Office of Cereal Investigations continued cooperation in work of cereal improvement and diseases of cereals; the forage crop investigations were continued with cooperation of the Office of Forage Crop Investigations; and during the biennium cooperation on a small scale was started with the office of Cotton, Truck and Forage Crop Disease Investigations in a study of nematode troubles; with the office of Pine Blister Rust Control in the Campaign to control White Pine Blister Rust; with the office of Drug, Poisonous and Oil Plant Investigations in an effort to improve varieties of mint for Oregon conditions; and late in the biennium cooperation of the Office of Fruit Disease Investigations was extended in a study of cranberry problems; the Moro Branch Station was continued in Cooperation with the Office of Cereal Investigations and the Branch Station at Hermiston in cooperation with the Office of Western Irrigation Agriculture Investigations. Cooperation with the Bureau of Chemistry for investigations of problems in horticultural products was arranged and active during the greater part of the biennium; the soil survey in cooperation with the Bureau of Soils was continued; cooperation with the Bureau of Farm Management and Farm Economics in a study of Cost of Wheat Production was started, and assistance in Drainage Problems was given by the Division of Agricultural Engineering, Bureau of Public Roads.

OUTSTANDING STATION ACCOMPLISHMENTS OF THE BIENNIUM

Progress in experiment station work of most far reaching value and influence—the foundation work which makes possible findings of immediate practical value—cannot be measured or exhibited in the form of striking, outstanding accomplishments. The following few illustrations, however, indicate the possibilities of results of practical economic value from station work in plant and animal breeding and land reclamation.

These few developments of the biennium, added to Turkey wheat for the Columbia Basin, O. A. C. No. 7 barley, former well known work with poultry, lime-sulfur spray, perfection of arsenate sprays, the work upon which our orchard practice in pruning, cover crop, fertilizers is based, the discovery of sulfur as a fertilizer for alfalfa and other similar but less known accomplishments of the Oregon Experiment Station work, are vital to present-day agriculture of the state.

FEDERATION WHEATS

In the Director's Report for 1918-1920 mention was made that 250 bushels of a new high-yielding spring wheat, Hard Federation, would be available for distribution to farmers in 1921 from the Moro Branch Station.

In a four-year trial Hard Federation and Federation, two wheats selected from Australian wheat varieties, have outyielded Early Baart more than 20 percent, and Early Baart had previously replaced Pacific Bluestem upon recommendation of the Moro Station because it had proved to be the highest yielder in the station experiments. Trials made by farmers in 1921 indicate that both of these new Federation wheats will be suited to practically all of Eastern Oregon. The Federation has also proved to be a high-yielding variety under irrigation. Both varieties have been widely distributed to farmers in every Eastern Oregon county, and results confirm the results of station trials that these varieties will soon be important commercial wheats.

A ten-percent increase in spring wheat yield in Eastern Oregon would exceed 297,000 bushels annually.

SMUT-RESISTANT WHEATS

A few pure-line selections of wheat varieties were discovered that are totally immune to both species of stinking smut. The discovery of these wheat varieties is likely to prove of much economic importance to the wheat-growing industry of Oregon and will probably mean the eventual elimination of the stinking smut nuisance from the state. This alone would mean an annual saving of several hundred thousands of dollars to Oregon farmers. Thus far the immune varieties are not equal in yield to the leading commercial wheats grown. Notwithstanding this fact the progress made and the possibilities are considered of outstanding importance.

HUNGARIAN VETCH

About sixty acres of Hungarian vetch planted in the fall of 1921 will be harvested for seed and the seed distributed to farmers of Western Oregon in 1922. In trials over a number of years this vetch has proved of outstanding value. It is suited to wet, unfavorable conditions, and is a better yielder for hay, silage, and seed, than other vetches. It shatters seed less readily than most of the other vetches, is more resistant to attack from aphis, and is a very good bee plant. In fact Hungarian vetch is believed to be the most valuable development for Western Oregon in the forage crop line in years.

A NEW RECORD FOR BARRED ROCKS

A new laying record for Barred Rocks was made during 1921 when the station Barred Rock hen K 24, completed her first year with 324 eggs at a laying contest in California. Further, this hen has not stopped laying for longer than seven days to date, July 1, 1922, since she began December 14, 1920, and in this period has laid 443 eggs in 562 days, an average of 78.8 percent production. Sixty-three eggs set for hatching in 1922 produced after about 14 months laying showed fertility of 95 percent. More than for the record itself this accomplishment is a measure of successful effort in the station breeding work to produce strains for high laying over a long period and with the vigor necessary to maintain such effort.

CONSTRUCTING DEEP DRAINS BY SLUICING

The development of sluicing as a method of constructing deep drains as worked out in cooperation with local people of Malheur Valley is of great importance in cheapening and advancing much needed drainage and reclamation in that section and for similar conditions elsewhere. The first drain 12 feet deep and about 1000 feet long was constructed by sluicing at a cost of approximately 17 cents per foot of drain, in connection with an experiment to drain and reclaim alkali land. Following this beginning in 1921 there has been constructed one drain 2226 feet long and 12 feet deep at a cost of 11 cents per foot of drain. On another drainage unit one mile of the ditch has been completed and another one-half mile is nearly completed. An additional 3½ miles are ready for sluicing. This district requiring about 6 miles of drains will be completed at a cost of about $15,000.00 as compared with the previous engineering estimate of $40,000. The directors of this drainage unit estimate a saving of $25,000 on the one unit alone from this finding.

NEW METHOD FOR CLEARING THE BIG STUMP LAND

The new method of removing stumps 24 inches and over in diameter originated by Mr. S. F. Zysset and developed by the Experiment Station in cooperation with Mr. Zysset is simple, practical, and of outstanding merit, reducing the cost of clearing the average big stump land fully fifty percent over previous methods.

BLIGHT-RESISTANT PEAR STOCKS

Pear blight is the greatest hazard in pear growing. Losses are large and in many regions have wiped out the industry. The only remedy now known is to cut out and destroy all affected portions and blighted trees.

The only solution appears to be in finding or producing stocks and varieties which will resist the blight. The branch station at Talent has made collections including the wild species from Europe, Asia, Africa, and all cultivated varieties of America, and cultivated varieties of Europe, Japan, and China.

A few have been found which are resistant to blight. Some of these immune types give great promise as blight-resistant stock on to which to top-graft commercial varieties. These types are being propagated as rapidly as possible, and if they continue to prove satisfactory will mean millions to the pear industry in the United States.

PRUNE DRYING

Recent experiments in recirculation of air and controlling humidity in the Oregon tunnel drier indicate a possibility of reducing wood consumption about one-half, labor about one-third, and at the same time producing a higher grade dried fruit product. Applied in practice, these findings may mean about $500,000 to the state annually. In addition, they will reduce cost of future drying plants about one-half from cost of the present day drier.

STATION IS UNABLE TO MEET DEMAND FOR INVESTIGATIONS

Every reasonable effort has been made to adjust expenditure of station funds and energies to meet demands and immediate needs for investigations. Notwithstanding this fact there have been many requests for assistance of a nature requiring thorough systematic study which could not be undertaken with the funds and staff available. The following are examples:

CRANBERRY GROWERS CALL FOR ASSISTANCE

The cranberry growers appealed for assistance in solving troubles from plant diseases, insects, and weeds which threaten the economic existence of the industry. The difficulties are of such nature that only thorough study will promise permanent relief. The station could not undertake such studies without discontinuing work on similar troubles of the larger fruit industries. Assistance from the Federal Department of Agriculture it is hoped will give some relief. But there is need of additional investigations.

SOIL SURVEYS REQUESTED

A resolution adopted by chambers of commerce in Eugene, Cottage Grove, and Meadowview, and by eight Granges, requested a soil survey of Lane county which cannot be started before late 1923 or 1924 unless funds for this work are increased.

A POSSIBLE BLUEBERRY INDUSTRY WAITS UPON EXPERIMENT STATION WORK

Assistance has been requested in determining the suitability of large areas of undeveloped land in Western Oregon for the growing of blueberries. The possibilities for this new industry are good, but its development waits upon information which can be secured only by study and experimentation concerning the soils, suitable varieties to grow, and methods of culture under Oregon conditions—problems which cannot be answered by mere observations.

DOUGLAS COUNTY URGES MORE WORK ON PRUNE DRYING

A resolution submitted by the Douglas County Farm Bureau "earnestly recommends that experimental work to determine the best type of drier and method of drying (prunes) be given all possible impetus and that appropriations and energy be provided which shall be commensurate with the importance of this question to the fruit industry of our county and state." This recommendation was founded on the fact that "prune growers are suffering annual losses running up into the hundreds of thousands, if not millions, because of inefficient drying practice." The Experiment Station has made real progress on this problem but the study still needed cannot be kept up without sacrificing other equally important investigations under way.

Resolutions have been received asking for investigations in behalf of several other industries and localities which it has not been possible to meet or to meet only to a limited degree as a matter of temporary relief.

OTHER UNSOLVED PROBLEMS OF EQUAL OR GREATER IMPORTANCE

Despite the fact that much has been done and is being done, I believe it my duty again to call attention to unanswered problems of far reaching importance to the agriculture of Oregon—problems which the Experiment Station is not studying at present or for which the present investigations are inadequate compared to the importance of the problems and the need for information.

COST OF PRODUCTION AND FARM MANAGEMENT STUDIES

During the readjustment of farming practices the past two years, there has been much need of reliable fact data regarding farm organization and combinations of farm enterprises suitable for diversified farming under different conditions of the state. A similar need has been apparent for cost of production data to assist in readjustment to changing market and labor conditions and to diversified farming. The station staff and the staff of the Extension Service have cooperated in an attempt to give the best service possible based upon the combined information of all members. Exact information such as comes from cost-of-production, farm-organization, and farm-management studies extending over several years has been seriously lacking. Such work demands the time of at least one man if material progress is to be made. The present station funds do not admit of this expansion into a new field. Funds for such work should be provided at the earliest opportunity.

MARKETING INVESTIGATIONS

There is growing need for systematic studies in the marketing of products of Oregon agriculture. The problems of this field also are of such nature that effort short of the time of one man of the best qualifications available would mean little in the way of accomplishment compared with the magnitude and complexity of the problems.

FARM CROPS PROBLEMS

The station investigations for the selection and development of better varieties of farm crops, more suitable cropping systems, and better methods of growing crops have been strengthened at the branch stations and to a slight degree at the Corvallis station. The investigations, especially at Corvallis for Western Oregon, are still inadequate to meet in reasonable time the needs and possibilities of this most important phase of agriculture.

There is need for more thorough, continuous work to find or develop forage crops and grains better suited to the soils, climate, and disease conditions of many sections of the state. The time and manner of working the soil and the time and way of planting crops have much

to do with securing the extra yield which means success. There is no profit in average or less than average production. When the variation in soils, and different requirements of crops are considered along with present difficulties of getting a stand of many crops and paying yields of others, the need and economy of more thorough field experiments are unquestioned. Likewise there is need for more thorough comparative experimental study of many crop rotation systems over a period of years for progress in the all important problem of keeping farming lands of the state permanently productive under systems of farming which will be profitable with changing conditions of markets, crop pests, fertilizers, labor, and machinery.

The problems of weed control and pasture development and of standardization of crops are not yet under investigation. Need of such information increases.

SOIL INVESTIGATIONS

Soil reclamation, improvement, and preservation are vital to development and permanency of profitable agriculture in Oregon. The problems are many and difficult. Investigations under way have shown good progress from the small appropriation granted for soil investigations by the legislature at its 1919 session, and again at its 1921 session.

This appropriation, however, covers soil fertility investigations, soil surveys, irrigation investigations, drainage investigations, and surveys of both prospective irrigation and drainage projects to determine their feasibility agriculturally. While a great deal of useful information has been secured and helpful service rendered, the investigations are entirely inadequate to meet the needs or the calls for immediate information on these important subjects.

Soil fertility investigations should be expanded so as to develop permanently profitable systems of soil management before the lands are worn to the point of unprofitable production. This will necessitate more field trials with fertilizers, supplemented by laboratory and greenhouse studies, and more thorough studies of soil management and fertility with diffferent crops and cropping systems.

The soil surveys constitute an invoice to the agricultural resources of the state and form the basis for effective use of information on crops and soil management already available and for further investigations.

The United States Bureau of Soils cooperates in this work and bears over one-half the expense.

Economical use of irrigation water is necessary if the highest productive land values are to be realized and retained under irrigation. Since the amount of water rather than the land is usually the limiting factor in Oregon, any saving from more economical use of water is vitally important. The amount of water and the methods of using it to give the best returns vary greatly under Oregon conditions and for different crops. More information is needed at once, and the investigations have reached merely the outskirts of the problems.

Drainage should eventually reclaim or double the productiveness of about 3,000,000 acres of Oregon lands. The most economical methods of draining and the management of wet, tide, overflow, and alkali lands,

require investigation to secure best returns from $75,000,000 or more that will be required for drainage reclamation in the state.

More information on these subjects from actual investigations and field tests for different conditions in different parts of the state are much needed both for agricultural development and for permanently profitable agriculture. To delay such investigations cannot but result in loss to the farmers and to the state. The problems are so distributed thoughout the state and conditions vary so much that the present appropriation of $7500 annually will provide at best for only limited investigations and tests useful for immediate guidance in agricultural practices, but not sufficient as a basis for more permanent agricultural practice.

CROP PEST AND HORTICULTURAL PROBLEMS

Breeding, Cultural, and Fertilizer Problems of Small Fruits. The acreage of small fruits has increased from 5132 acres in 1909 to 13,652 acres in 1921 in Oregon. The crop value in 1921 is estimated at $3,378,000 including loganberry, strawberry, raspberry, blackberry, and dewberry, cranberry, currant, and gooseberry.

This industry as a whole, and each crop, to be successful represents highly specialized agriculture with many problems in cultural practice, breeding for better varieties, and soil fertility. Field conditions and variations in yields as well as constant demand for advice as to the suitablility of new areas for growing small fruits and concerning difficulties where the industries are established emphasize the importance of investigations into the problems of this industry.

Orchard Fertility. There are in the Willamette and Umpqua valleys of Oregon about 42,500 acres of prunes, apples, peaches, cherries, and walnuts grown under great variation of soil and available soil-moisture conditions. Preliminary experiments indicate that important difficulties of maintaining vigorous trees and contro'ling diseases as well as profitable yields are greatly influenced by soil and soil-fertility problems.

The possibility of increasing financial returns annually is estimated at $1,000,000. The problems are such that thorough investigation over several years is necessary for reliable results and recommendations.

Small Fruit Diseases and Insect Pests. The berry industry is developing with great rapidity and promises to be of permanent and increasing value. Over 13,000 acres are now devoted to berries in Oregon, with a crop worth over three million dollars, as against about 5,000 acres only twelve years ago. No systematic study of the diseases or the insect pests of small fruits has been undertaken thus far, while many very destructive troubles are appearing, the nature of which is little known, or entirely unknown. Dieback of loganberries, causal organism unknown, resulted in about 25 percent loss of crop in Oregon in 1921. Dying out of hills in the best soils is an increasing trouble, and the cause is unknown. Nothing is known of practical control for bluestem of black caps. There are some fifteen recognized insect pests of small fruits in Oregon doing sufficient injury to limit production. No investigations are under way.

Walnut Blight. Walnut blight causes a loss of about 25 percent or the annual crop of Oregon. Walnut acreage is now about 3,000 acres and rapidly growing. No practical control method is known. The annual loss is already estimated at $30,000 to $50,000.

Filbert Bacteriosis. Great mortality results from this disease in young plantings of favored varieties. The industry is growing with extreme rapidity. Probably 300 acres are planted and the acreage promises to more than double itself in two or three years. The annual loss in two- and three-year old plantings is probably about 10 percent. No control method is known.

The Bee Industry Needs Assistance. *Artificial Control of Queen Mating.* Oregon has approximately 100,000 colonies of bees with an annual production of honey of from $500,000 to $1,000,000. The beekeeping industry suffers a loss annually of close to $50,000 from disease. This loss is largely due to European foul brood in Western Oregon, where it is very difficult to secure pure mating of young queens, a factor that is very essential in the control of this disease. Young queens almost invariably mate with inferior drones from the timber.

Winter Protection for Bees. The climatic conditions of Oregon and Washington west of the Cascade Mountains make it desirable to determine if possible the most economical and satisfactory method of protecting bees for the winter in commercial yards. More successful methods of wintering would make it possible to increase our surplus production of honey by the maximum collection of nectar from the earlier abundant flows.

Grasshoppers. In the greater plain area of Eastern Oregon the grasshopper problem is a serious one. Preliminary studies indicate that the serious losses are avoidable. Until the problem is more definitely investigated, in order to work out and demonstrate satisfactory methods of grasshopper control, however, emergency calls for assistance will continue to reach the Experiment Station at times when serious losses cannot be entirely prevented and the cost of combating the outbreaks will be very heavy.

Animal Nutrition in Relation to Production and Diseases. Oregon's dairy products are estimated at over $17,000,000 and poultry products about $10,000,000 in 1921 by F. L. Kent, the Federal Agricultural statistician. Both industries are developing. Climate and agricultural conditions favor intensive high production in both industries as shown by world's records made in the state in milk and butter-fat production and in egg production.

These industries are confronted with serious problems in maintaining vitality of the animals and controlling losses in stock and in production from diseases under the strain of high production. The losses annually are estimated at $3,000,000 or more.

The probability of these difficulties being closely associated with questions of nutrition makes urgent a thorough investigation of this subject in combination with investigations now under way on infectious abortion, sterility and related troubles in cattle, and diseases of poultry.

MISCELLANEOUS SERVICE

Members of the station staff are called upon to assist in a variety of ways in connection with agricultural activities on the campus and throughout the state. This service is among the most valuable rendered to the state by the institution. On the other hand it cannot be performed without retarding and limiting the accumulation of facts on problems which the people of the state want solved. It is almost daily a matter for decision as to where the best service can be rendered.

The small staff in Farm Crops at the home station, for example, spent over 100 man days' time during the fiscal year ended June 30, assisting the Extension Service throughout the state. And in addition there were letters and conferences without end for this department. This case is perhaps somewhat extreme yet the small staff of Entomology spent 182 days' time answering emergency calls for assistance throughout the state during the biennium. The staff in Horticulture estimate about 11,000 to 12,000 interviews and conferences, 110 addresses and 60 tours with visitors over the campus and station in addition to letters and committee meetings. For the month of May 20 to June 20, 1922, the Hood River Branch Station received 240 telephone calls for information, 233 office visits for information, and answered 86 letters, besides sending out 1500 circulars of information. This is about an average for a six-months period and is typical of the time devoted to miscellaneous service at branch stations and by the Departments on the campus, a popularity appreciated but at times promising disaster to further experimental work.

IMPORTANT NEEDS OF THE STATION

The discussion immediately preceding is merely a brief, frank statement showing the many worthy calls and needs for investigations which the Experiment Station cannot meet at once or in the near future with its present resources without discontinuing similar, equally important investigations. They represent needs of farmers, of agriculture, and of the state, however, rather than needs of the station, except that the station could not undertake the investigations without additional funds. Regardless of expansion in the program of investigations the station needs additional land, greenhouses, store room, and equipment. For lack of these facilities, important investigations have had to be discontinued before ultimate solution is reached and progress on many other studies is retarded or limited.

GREENHOUSES

At the present time the station greenhouse space is limited to one small section. There is no space provided with control of temperature and humidity, features which most stations have today. The limited space and lack of controlled conditions result in a corresponding limitation in amount and character of investigations needing greenhouse space in connection with soil studies, crop improvement, horticultural problems, and plant diseases. It is hoped that the institution may find a way in the near future to construct adequate greenhouse facilities.

LAND

Many of the most important station investigations with farm crops and soils and plant diseases are now on rented land with no certainty that the College will control the land long enough to carry the studies to logical conclusion. And there are other experiments which should be undertaken as soon as college-owned land will assure continuation for the period necessary to get results.

The orchard site now used is not suited for experimental work of the future. When this tract was chosen nine or ten years ago many phases of soil and orchard management were not as well understood as they are today. The present location has served to answer many problems of site which would not have been answered on an ideal location. The soil, however, is too heavy and soil drainage as well as air drainage are inadequate for orchard purpose. There is almost no hope of bringing to bearing a commercial orchard or of growing with assured success trees or small fruits for experimental purposes.

The tract now used for orchard purposes, except perhaps a small area, should be considered for use to meet a real need for land by the livestock department, and a tract of 90 to 100 acres should be secured suitable for horticultural uses, mainly experimental. With an investment of fifty to sixty millions of dollars in the fruit industry of the state depending upon the Experiment Station to do the needed experimental work I cannot emphasize too strongly the importance of early consideration of this need for land if the Experiment Station is to continue to redeem its responsibility to the fruit industry and to the state.

There is need also for a demonstration orchard. Many facts developed experimentally need testing on a commercial scale before they can be recommended to growers without reservation Some of the state institutions have met this need by leasing orchards for demonstration purposes. The Iowa Agricultural College, the Missouri College of Agriculture, and the New York Station at Geneva have one or more orchards leased.

As a typical example of such need the station results on sweet-cherry pollination may be cited. In 1911-12-13 experiments by the station brought out the fact that important varieties are inter-sterile. This information with suggested remedies was published and has been used by Extension men, but still the fact remains that only 5 to 10 percent of the growers took advantage of the findings and suggestions and instead of saving about $1,500,000 annually there is a saving of $70,000 to $80,000. Many growers say, "We have never seen it tried out commercially and we are willing to let the other fellow do the experimenting." If the station had a demonstration orchard the commercial demonstration would immediately follow the developments by experiments and commercial application generally could be speeded up. Many new methods and station findings will pay for all experimental work in one year, and every year of delay in their application is a direct loss.

REPAIRS AND REPLACEMENTS

The south poultry farm is much in need of a foreman's cottage, new fencing, paint, and general repairs. A small amount only has been expended on maintenance and repairs since the original construction work.

SEED HOUSE AND STORAGE HOUSE

A seed and storage house suitable for use by all departments is badly needed. At present there is difficulty and not infrequently failure to save what is grown of valuable seeds stocks.

EQUIPMENT

The station is far short of adequate equipment at Corvallis. The greatest immediate need is a threshing machine and a nursery thresher. Little equipment has been purchased during several past years, and there comes a time when equipment is imperative to further work.

PUBLICATIONS

During the biennium the station has published eighteen bulletins, three circulars, and four reports, including the Third Crop Pest and Horticultural Report, containing thirty-eight papers. In addition many technical papers reporting original research data have been published in leading technical journals of the country. This large number of publications has been possible only by putting out editions limited to 3000, 4000, and 5000 copies. Larger editions would have meant a reduction in number of publications in approximate proportion to increase in size of editions.

The limited editions have many disadvantages. It is not possible to maintain an individual mailing list either within the state or for outside individuals; even the many new applications for library copies must be scrutinized carefully before approved; and with these precautions many of the station editions are exhausted within three months to one year. Favorable comment is received for the promptness and form of publications, and there is demand for publications on additional subjects. On the other hand there is complaint that new publications are exhausted within a few months and because mailing lists of individuals are not maintained.

The Experiment Station has a first obligation to make known its worth-while findings as promptly as possible. If the results are valuable and are in sufficient demand a way should be found to increase editions sufficient to meet at least the state demand for the popular bulletins and a reasonable distribution outside the state in exchange for out-of-state publications. The time has come when one of three conditions is inevitable: a special printing fund must be provided to meet the increasing demand for station publications; the demand cannot be met; or the station must greatly limit its primary function of solving problems in order to increase the size of editions by four times and become a teaching agency.

The present policy of getting material in printed form as timely as possible will be continued as of first importance even if necessary further to limit editions. And it is hoped the findings will be of sufficient value to warrant additional support for publications.

BULLETINS

Number	*Title*	*Edition*	*Pages*
173	Irrigation of Potatoes	3000	28
174	Fattening Steers	5000	16
175	Fattening Lambs—Shelter versus Open Lot	4000	11
176	The Relation of Carbohydrates and Nitrogen to the Behavior of Apple Spurs	3000	47
177	The Management of Sandy Soils Under Irrigation	3000	26
	Third Crop Pest Report	5000	204
	Oregon Soils Investigations 1918-1920	3000	46
	Director's Report 1918-1920	5000	80
178	Farm Drainage	4000	47
179	Poultry Housing	5000	22
180	Egg Laying Characteristics of the Hen	3,000	96
181	Orchard Management	5000	36
182	Growing Steers	5000	15
183	Shelter and Warm Water for Fattening Steers	5000	11
184	Silage for Fattening Lambs	5000	7
185	The Management of Willamette Valley Soils	5000	11
186	A New Test for Maturity of the Pear	5000	28
187	The Principal Stock Poisoning Plants of Oregon	5000	42
188	The Wheat Bunt Problem in Oregon	5000	43
189	Irrigation of Alfalfa	4000	35
190	Wheat Growing After Fallow in Eastern Oregon	10,000	35
	Soil Report of Multnomah County (In Cooperation with U. S. Dep't of Agric., Bureau of Soils)		

CIRCULARS

Number	*Title*	*Edition*	*Pages*
23	Vegetable Gardening in Oregon	5000	43
24	Potato Diseases in Oregon and Their Control	5000	53
25	Seed Potato Improvement	8000	7

JOURNAL OF AGRICULTURAL RESEARCH

(1) Transmission of some wilt diseases in seed potatoes.
(2) Further Studies on Relation of Sulfates to Plant Growth and Composition.
(3) The Influence of Temperature and Evaporation upon the Development of Aphis pomi.
(4) Studies in Physical and Histological Changes of the Pear Fruit.

SUMMARIES OF PUBLICATIONS

REPORTS

Third Crop Pest and Horticultural Report.

The December Freeze: Some Lessons from it, W. S. Brown.

A brief description of the different manifestations of winter injury is given together with notations on varieties most apt to be affected, influences of soils, air drainage, etc. The summation includes a number of lessons for fruit growers from the December freeze of 1919.

Summer Pruning of Young Trees, E. M. Harvey.

No form of summer pruning is as favorable to the tree growth and spur development as winter pruning only. Summer pruning can be recommended only under special conditions.

Some Relation of Growth and Bearing of Fruit Trees to Orchard Practices, E. M. Harvey and A. E. Murneek.

Factors involved in the maintenance of the orchard are discussed; particularly as to the alternative cultural practices which should bring about similar responses in the trees, thus suggesting a broader and more flexible basis for controlling the growth and bearing of the orchard.

Storage of Bosc Pears, A. E. Murneek.

It was found that the time of picking did not greatly influence the keeping quality except that fruit picked very early should be partly ripened under more humid conditions and for a longer period than that picked much later. Fruit may be kept three months longer by giving the fruit a delayed storage of 10 to 15 days at ordinary temperatures than when given 12 to 15 days at refrigerator-car temperature at a humidity of 60 to 70 percent.

Cherry Breeding, C. E. Schuster.

A report on the progress of cherry breeding work at the central Experiment Station. Special matters noted in the report are self sterility and inter-sterility of the sweet cherry seedlings, freedom from disease, especially calling attention to excellent fruit that has been produced on a relatively high proportion of the seedling cherries.

Pollination of the Ettersburg No. 121 Strawberry, C. E. Schuster.

This paper deals chiefly with the description of the variety Ettersburg No. 121 introduced from California within the past few years. It has been found that this variety is especially vigorous and carries its load of fruit high upon erect fruiting stems, that it is a heavy producer, and that its fruit is fine both for canning and for shipping, and finally it has a long blooming season. This variety is now being used as one of the parents in a large number of crosses that have been made and are being made.

Some Investigations on Prune Drying, E. H. Weigand.

This article takes up methods of harvesting with suggestions for improvements, the loss to the grower due to over-drying, dipping in boiling water compared with lye dipping, location of the drier, artificial and natural draft, and the benefit of higher humidity in tunnel driers when accompanied by rapid air movement.

Vegetable Greenhouse Crops in Relation to the Use of the Greenhouse for one Season, A. G. Bouquet.

It was found upon taking a survey of the state that a good many greenhouses are idle during the greater portion of the season due to the decline of the market for leaf lettuce. Trials conducted by the Experiment Station show that spinach, cauliflower, radishes, cucumbers, and tomatoes can be grown as profitable substitutes for leaf lettuce.

Factors Affecting Production and Marketing of Broccoli, A. G. B. Bouquet.

In summarizing data obtained over a number of seasons, it is clearly seen that there is a marked difference in the value of broccoli seed strains resulting in a considerable increase in yields per acre and in the quality of the broccoli to be marketed. The practice of growers purchasing their seeds from many different sources is to be discouraged. It is more desirable to purchase from reliable sources and from strains known to be tested and found good. Inspection of broccoli fields to recommend the best type of broccoli grown for seed is suggested.

Factors Affecting Shrinkage and Conditions of Broccoli, A. G. B. Bouquet.

Broccoli growers have been troubled by reports showing that the broccoli arrived at market centers in a discolored and wilted condition. The broccoli grower is advised not to allow the head to become too old before cutting and that icing, packing, etc., be looked after very carefully. The most important characteristics of broccoli heads are pointed out: whiteness of curd, solidity of curd, green jacket leaves, and curd free from blemishes.

Depth of Planting in Relation to Tree Growth, Henry Hartman.

Briefly it was found upon digging and examining the root systems of the trees planted at depths ranging from nursery depths to 27 inches below nursery depth, that there seemed to be little difference in the growth of the trees under these extreme conditions. Variations as to size and thrift occurred of course, but these could be accounted for by soil, individuality of trees, and other sources aside from the depth of planting.

Fertilizer Experiments with Fruits, L. P. Wilcox.

This article deals with the influence of nitrate of soda applied as fertilizer upon Italian prunes and upon red raspberries. Amounts of nitrate running from 3½ to 5 pounds to the tree gave the best results on prunes, and it was found in old devitalized orchards that an increase in tonnage amounting to as high as 33⅓ percent in some cases was obtained. It may be said that on the average 25 percent increase may be expected from that type of tree. The nitrate of soda upon red raspberries showed approximately a 10 percent gain in fruit produced, together with larger berries, better luster, and a larger and more glossy leaf. It was found however that the stimulation which the cane fruits received during the summer of 1919 resulted in a somewhat increased amount of winter injury due to the extreme cold of December, 1919.

Wood Decay in Orchard Trees in Oregon, S. M. Zeller.

Attention is called to the prevalence of decay of wood in Western Oregon orchards, particularly in prune and peach trees. The need of adopting preventive measures in orchard practice is brought out. Such measures are suggested.

A Serious Nematode Disease of Strawberry and Clover in Oregon, M. B. McKay.

Attention is called to the occurrence of a serious disease of a number of our important crops in the state, and the appearance of the disease is described so that growers may readily recognize it. Control measures are presented. *Reprinted.*

Peach Leaf-Curl Control, H. P. Barss.

A description of this destructive disease is followed by an account of three years' tests on control showing the superiority of bordeaux mixture over sulfur compounds and other materials. Records are given showing the advantage of an early winter or mid-winter spray over a last-minute spray before the buds burst.

Gooseberry Mildew Control, C. E. Owens.

Description of the disease and discussion of two years' experimental results on control. Lime-sulfur applied in early spring and at intervals proved effective.

Cylindrosporium Leaf Spot of Prune and Cherry, H. P. Barss.

Discussion of the disease and presentation of results of control experiments demonstrating that the disease can be held in check by bordeaux mixture.

Physiological Disorders of Developing Fruits, H. P. Barss.

A discussion of certain common and troublesome disorders of apples, pears, prunes, grapes, etc. not of parasitic origin. Suggestions for lessening the danger of such difficulties are given.

Notes on Tests with Fungicides. H. P. Barss and W. A. Smart.

Results on apple fruit of late summer sprays for anthracnose control. Tests with sugar as a stabilizer for Bordeaux. Discussion of the use of iron sulfide in lime sulfur sprays. Comparison of results of tests between ordinary lime-sulfur and dry lime-sulfur for fruit disease control.

Control of Moss and Lichens in the Orchard, W. A. Smart.

Presentation of results of tests showing the advantage of Bordeaux over lime-sulfur for permanency of protection against these epiphytes.

Western Yellow Tomato Blight, M. B. McKay.

Briefly describes and gives known control measures for this serious tomato disease that is the chief limiting factor in the growing of tomatoes in a large part of our own state.

Mosaic Disease of Tomatoes, M. B. McKay.

Describes this disease which has formerly not been known to occur in the State of Oregon. During the past two years it has been causing very serious damage in some greenhouses in the State although its destructiveness is not limited entirely to the greenhouse. Control measures are listed.

Blossom-end Rot of Tomatoes, M. B. McKay.

This disease is described and its nature briefly discussed. The measures that are known for its control are detailed.

Onion Smut Control, H. P. Barss.

Discussion of this destructive disease which has invaded the onion sections of Western Oregon, resulting in the abandonment for onion culture of valuable acreages. Experiments on the use of various methods for the control of the disease conducted at Hubbard, Oregon, in 1918 are described and the results are presented showing that

formaldehyde 1 oz. to the gallon of water is effective if applied in sufficient quantity to the drill row at seeding.

Bean Blight and Bean Mosaic, H. P. Barss.

A brief description of these two serious diseases which have appeared in Oregon. Rogiing is suggested as a means of reducing mosaic in the bean seed plot.

Grain Smuts and their Control, H. P. Barss.

A description of the principal smut diseases of grain in Oregon with presentation of methods of control by seed treatment designed to reduce to the minimum the danger of seed injury. *Reprinted.*

The Western Peach and Prune Root-borer, F. H. Lathrop and A. B. Black.

Includes brief historical sketch of insect in Oregon and earlier attempts at control. Discussion of life-history studies and control investigations. Of many treatments tested including asphaltum, protectors, and various washes, whitewashes containing repellent substances give the most promise of protection.

Improved Sprays and Practices in Codling-moth Control, Leroy Childs and A. L. Lovett.

A summary of investigations to date as applied to practical codling-moth control. Powdered arsenate is considered the preferable form. The addition of spreaders to the poison spray solution tends to improve control. High powered, big capacity spray outfits are preferable especially for use with the spray gun and on large tracts. The gun can work efficiently only where capacity of outfits is adequate. Dusting, generally, has not given control comparable to the liquid spray: wind is a serious limiting factor in the use of dust in the Hood River Valley.

The Fruit Tree Leaf-roller—Report on Progress of Investigation, B. B. Fulton.

A resume of investigational work in Oregon to date. A discussion of the species with life-histories and recommendations for control. The heavier miscible oils, about 8 percent solution gave best results in control.

Chemical and Physical Properties of the Lead Arsenates, R. H. Robinson.

A study of the comparative chemical and physical properties of commercial brands of lead arsenate. From the standpoint of poison content all are approximately equal. There is some variation in their physical properties; theoretically those are best which are most uniformly finely divided. Some commercial leads have spreaders incorporated in them.

The Pear Thrips, A. L. Lovett.

A preliminary report of the presence of the insect in the state, its known distribution, and a suggested calendar of spray applications for control.

Flat-headed Borers which Attack Orchard Trees and Cane Fruits in Oregon, W. J. Chamberlin.

A general description of the group, their habits, injury, and control. The various species, their hosts and economic importance follow.

Grasshopper Control in Oregon, B. B. Fulton.

Grasshopper outbreaks are of periodical occurrence in Oregon. The seriously destructive forms are the migratory species of Eastern and southern Oregon. *Camnula pelucida* is the most common offender. This species chooses fairly well defined areas of waste land for egg deposition and tends to return to these areas in the fall for egg laying. Control methods of recent development are discussed briefly, then the control campaigns carried out in Harney and Grant counties are given. In closing, a definite outline of a control campaign is given. (1) Organization of the people in the infested district is essential. (2) Arrangements must be perfected for obtaining the necessary funds for the purchase of materials and for the labor. (3) Surveys of the egg beds must be made in the fall. (4) When the young hoppers begin hatching, united effort in mixing and scattering the poison bait over the egg beds is advised.

The Alfalfa Weevil, B. B. Fulton.

A popular compilation of the present essential knowledge of this insect, its life-history, injury, and control.

The Loganberry Crown Borer. A. L. Lovett.

A brief historical sketch of the pest in Oregon. Notes on the habits, hosts, life-history, and experiments on control follow. Taking advantage of the habit of the half-grown borer in coming above ground to girdle the new canes in early summer, the severing and removal of these girdled canes is advised. *Separate.*

Amounts of Spray Required on Trees of Different Ages in the Different Applications, Leroy Childs.

A very practical presentation of some facts gleaned in connection with investigations at Hood River on the amount of spray required per tree where growers are getting uniformly good results in control.

The Rusty Leaf-mite, F. H. Lathrop.

An obscure foliage trouble occasionally serious on pear and prune is apparently due to this microscopic mite. Brief notes on injury, distribution, life-history, and suggested control measures are given.

Tree Crickets, B. B. Fulton.

The canes of loganberries and raspberries often split or break off due to the weakening effect caused by the egg punctures of tree crickets. The injury is generally prevalent in the cane fruit plantings in Oregon. Often these punctures into the cane become points of infection for canker and blight diseases. Cutting out the heavily infested canes is advised.

Director's Report 1918-1920. A statement of problems and needs of the Experiment Station and brief report of results of investigations by Departments and Branch Stations.

Oregon Soils Investigations. Summary report of soils investigations for two years and suggestions as to a program for future investigation.

STATION BULLETINS

173. **Irrigation of potatoes,** W. L. Powers and W. W. Johnston.

This bulletin reports twelve years' experiments in irrigation of potatoes. Time, amount, and frequency of irrigation, the water requirements of potatoes, the influence of irrigation, crop rotation, and fertilizers upon the crop are discussed.

174. **Fattening Steers,** E. L. Potter and Robert Withycombe.

Reports results of six years' feeding tests in fattening steers. Results from feeding alfalfa hay alone, chopped alfalfa, alfalfa hay and grain, and alfalfa hay and silage are presented. Results with silage show remarkable gains.

175. **Fattening Lambs; Shelter vs. Open Lot,** E. L. Potter and Robert Withycombe.

Reports three years' results of fattening lambs with shelter sheds as compared with fattening in the open. The amount of feeds used and daily gains are given.

176. **Relation of Carbohydrates and Nitrogen to the Behavior of Apple Spurs,** E. M. Harvey and A. E. Murneek.

I. Effect of Spur Defoliation on the Formation of Fruit Buds, E. M. Harvey.

It was found that fruit-bud formation is dependent upon the activity of the leaves of the spur, that the individual spur acts as a unit and almost independent of the tree as a whole. Simultaneously with the decreased fruit-bud formation on defoliated spurs went a constant change in the food constituents of the spur, showing the dependence of the spur on its own leaves for its food materials. Thus the results offer a further explanation of the observed external behavior of the spur.

II. Effects of Spur Defoliation on the Setting of Fruit, A. E. Murneek.

It was found that the set of fruit was practically proportional to the leaf area of the individual spur. Chemical studies were made at the same time and the results again show the dependence of the activity of the spur on the food product of its own leaves.

177. **The Management of Sandy Soils Under Irrigation,** H. K. Dean.

This bulletin treats on the preparation of land, and the methods of applying irrigation water, particularly the adoption of the border method to the sandy soils, their width, length, shape, and suitable heads for their irrigation. The use of straw or rye cover is recommended. Experiments with different amounts of manure, the carrying capacity of grass pastures, are reported.

178. **Farm Drainage,** W. L. Powers and Ward Cretcher.

Describes different types of wet land, reports results of experiments to determine the most suitable depth, distance apart, and size for field drains as well as methods of installation. It also gives information regarding the management of drained lands.

179. **Poultry Housing,** James Dryden.

A popular bulletin of information relative to soils, drainage, air drainage, sunshine, and other points in locating the poultry house, space required per fowl, requirements of ventilation, protection from cold and storms, and advantages and disadvantages of flooring. The portable house and commercial laying house are discussed, and plans and specifications are given for different size units. Desirability of yards, their size, use, and management, crops for green feed and range, and other matters pertaining to the care and welfare of the flock are discussed briefly.

180. **Egg Laying Characteristics of the Hen,** James Dryden.

A report of results and conclusions in part of twelve years' work of selective breeding to increase egg production. Variation in egg production, selection on the basis of high production as a method of increasing production, the desirability of testing the breeding quality of stock for breeding purposes, the relation of rate of laying to annual production, production during the first two months of the laying year or during spring months or late summer and fall as a measure of annual production, the influence of vigor and environmental factors upon production, comparison of first years' production with that of subsequent years, and correlation between rate of laying and fat content of eggs are discussed. The main conclusions are (1) high fecundity is inherited; (2) selection of breeding stock on the basis of annual trapnest production regardless of prepotency or tested qualities is a certain method of increasing egg production; (3) some hens and some males have the power of transmitting high fecundity; others have not this power. Therefore more rapid progress will be made in increasing the production of the strain if only those hens and those males be used in the breeding pens that have shown by the egg records of their pullets, or by the progeny test, that they possess the power of transmitting high egg production.

181. **Hood River Apple Orchard Management with Special Reference to Yields, Grades, and Value of Fruits,** Gordon G. Brown.

A six-year summary, 1913 to 1918, of apple orchard economics in Hood River Valley. A wide variation in yields and in gross annual value of packed fruit to the acre is shown. Facts are presented relative to the factors of orchard location, cultivation, fertilizers, irrigation, pruning, thinning, and varieties upon production.

182. **Growing Steers,** E. L. Potter and Robert Withycombe.

A report of tests from 1916 to 1921 conducted to determine economical methods of growing beef steers, as calves and as yearlings, using common feeds, stubble and meadow pastures and mountain range. A complete record was kept of feeds and gains for the summer, fall, and winter periods. A summary of results is given under the Union Branch Station.

183. **Shelter and Warm Water for Fattening Steers,** E. L. Potter and Robert Withycombe.

Reports tests in 1919-20 and 1920-21 to secure information relative to the value of barn shelter, open shed, and warm water as compared with lack of shelter and cold water respectively in fattening steers and calves. Results summarized as follows: Fattening steers, fed and sheltered in the barn and having access to a lot for exercise, consumed the same amount of feed and made very little more gains than those fed in the open. Fattening calves, given access to a shelter shed, consumed the same amount of feed and made the same gains as did those without the shed; fattening steers, given water warmed to an average of 43 degrees, consumed the same amount of feed and made the same gains as did those which received cold water.

184. **Silage for Fattening Lambs,** E. L. Potter and Robert Withycombe.

A report of feeding tests in 1918-1919 with peas-and-bald-barley silage for fattening lambs; and of tests in 1920-21 with sunflower silage. The results summarized are: (1) alfalfa hay and bald barley constitute a very satisfactory ration for fattening lambs; (2) silage added to a ration of alfalfa hay and barley does not increase the gains materially, but may be used in connection with fattening lambs, provided it can be produced economically; (3) in terms of amounts of feed replaced per 100 pounds gain where alfalfa hay is valued at $8.00 and barley at $25.00 per ton, peas-and-bald-barley silage has a value of $5.05 and sunflower silage $3.96 per ton for fattening lambs; (4) lambs fattened on alfalfa hay and barley, with and without silage, made very satisfactory gains and there was no apparent difference in the final condition of the finished lambs.

185. **Management of Willamette Valley Soils,** Department of Soils and Agricultural Chemistry.

A preliminary report on the improvement and maintenance of the Willamette Valley soils, giving a key to the soil classification used in the soil survey in the Willamette Valley and the first 100 chemical analyses of official samples of soil types in connection with the survey. Results of fertilizer and reclamation experiments are also briefly cited, composition of crops and of more common fertilizers are given, and recommendations are made as to the management of the main classes of soils in the Valley, based on rotation, fertilizer, and reclamation studies.

186. **A New Test for the Maturity of the Pear,** A. E. Murneek.

A complete description of the new "pressure testing" machine for determining the maturity of the pear. A summary of the results of three years' work with this machine is given and the correct procedure for its use described.

187. **The Principal Stock-Poisoning Plants of Oregon,** W. E. Lawrence.

Describes the principal stock-poisoning plants of the State, mentions a number of minor ones, and presents recommended methods for the reduction of stock-poisoning or the eradication of the plants responsible.

188. **The Wheat Bunt Problem in Oregon,** D. E. Stephens and H. M. Woolman.

Describes the experiments conducted in Oregon over a series of years by the United States Department of Agriculture, the Moro Branch Station, and the Central Station, cooperating, on seed treatment of wheat for the prevention of stinking smut, the most serious disease of wheat in the State, with recommendations for treatment methods designed to reduce seed injury from treatment to the smallest possible amount. Records also the tests of a large number of varieties and strains of wheat from all parts of the world for resistance or susceptibility to stinking smut as a result of which several immune and highly resistant varieties have been found which will serve as a basis for further breeding and selection, with a view to the eventual elimination of the smut problem in the state by the substitution of highly resistant commercial varieties for the susceptible kinds now grown.

189 **Irrigation of Alfalfa,** W. L. Powers and W. W. Johnston.

This bulletin points out that meadow crops are the most important in acreage under irrigation and require about twice the water that annual crops need. It presents data as to the duty of water for different valleys of the state. Experiments as to time and frequency of irrigation are also reported as are those giving the great effect of manure and crop rotation in decreasing irrigation requirements and water requirement.

190. **Wheat Growing After Fallow in Eastern Oregon,** D. E. Stephens, and G. R. Hyslop.

A popular bulletin based upon twelve years of experimental data, mainly from the Moro Branch Station, and thorough knowledge of conditions and practices in Eastern Oregon. The acreage and yield of winter and spring wheats are given by counties of the state for 1919-1920-1921. The leading varieties, comparison of varieties, and suggestions for change in varieties are given, and all phases of production are discussed, based upon experimental data supplemental by results in commercial production. The bulletin is essentially a handbook for wheat growers in the section under consideration.

Soil Report of Multnomah County, by C. V. Ruzek, Oregon Experiment Station, and E. G. Carpenter, U. S. Bureau of Soils (published by the U. S. Department of Agriculture).

This report will contain a soil map showing each soil type in color, description of each soil type, and recommendation as to the management of the important soils of the county.

STATION CIRCULARS

23. **Vegetable Gardening in Oregon,** A. G. Bouquet.

The first part of this circular contains a general description of such topics as the production of vegetables for local markets, the cooperative production of truck crops, production of vegetables for canneries and dehydrators, greenhouse vegetables, approved varieties of garden vegetables, and importance of well-tested seed strains. The

second part of the bulletin takes up methods of management, briefly including such topics as the use of frames, soil treatments for diseases, soils for vegetables, fertilizers, irrigation, insect pests, and cold storage. In conclusion, methods of handling the most important garden vegetables are given in some detail.

24. **Potato Diseases in Oregon and Their Control**, M. B. McKay.

This is in the nature of a brief handbook of the common potato diseases in the state. Twenty-four diseases are described and control measures are specified. It is especially designed to enable growers to recognize accurately the different diseases and to apply efficiently the different methods of control.

25. **Seed Potato Improvement**, G. R. Hyslop.

A brief statement pointing out the need for improvement in seed potatoes emphasizing especially the disadvantage of too many varieties, the reason for unproductive hills, poor stands, and the importance of sufficient plant food. Suggestions are given for improvement of seed by selecting seed tubers, examination to discard diseased tubers, treatment to minimize disease, and by methods of cutting for seed. Suggestions are given regarding soil, seed-bed preparation, planting, roguing, harvesting, and storage of potatoes.

TECHNICAL PAPERS

Owing to limited funds for publication a number of technical manuscripts reporting original data and results of research were published in technical Journals rather than as technical bulletins of the station series. In addition the shorter technical papers listed here by title only were published in Journals.

Transmission of some wilt diseases in Seed Potatoes, M. B. McKay. Jour. Agr. Research 21: 827-848. September 1921.

Presents as a technical report the results of four years of investigation on wilt disease transmission in seed potatoes. The data clearly show the serious losses due to wilt diseases borne in seed tubers of healthy external appearance and point to the imperative necessity of the inspection and roguing of fields devoted to seed production to insure reasonable freedom of the seed from internal infection.

Further Studies on Relation of Sulphates to Plant Growth and Composition, H. G. Miller, Jour. Agr. Res., Vol. 22, No. 2.

The influence of Temperature and Evaporation upon the Development of Aphis pomi, F. H. Lathrop, Jour. Agric. Research. In press.

Under normal outdoor conditions there is a general correlation between atmospheric evaporation and the rate of development of *Aphis pomi*

Atmospheric evaporation, as measured by the standard evaporimeter used, does not serve as a satisfactory index to the rate of development of the aphids.

Temperature, during periods when no other factor limits the rate of development of the species, constitutes a more satisfactory index than does atmospheric evaporation.

The relation of temperature to the rate of development of *Aphis pomi* may be expressed as a definite equation and represented by a definite hyperbolic curve.

Plant growth may constitute the limiting factor in the rate of development of *Aphis pomi.*

Studies in Physical and Histological Changes of the Pear Fruit, A. E. Murneek. To be published in Journ. Agr. Res.

This is a technical study of the gradual changes which take place in the outer layers of the pear during the harvesting period. The results disclose some of the factors involved in the regular and gradual decrease in resistance of the tissue to pressure. In other words an explanation of the practical pressure test for pear maturity is thus offered.

Physiological studies on the Effects of Formaldehyde on Wheat, W. M. Atwood. (In press. Bot. Gaz.)

An account of experiments conducted with a view to explaining the reasons for the injury experienced in the treatment of wheat with formaldehyde for smut control.

The Indian Meal Moth, A. L. Lovett, Bien. Rept. Oreg. State Bd. Hort. 1921.

Of a variety of serious pests of stored food products, cereals, evaporated fruits and vegetables, walnuts and confections in the Northwest, the Indian meal moth is by far the most cosmopolitan in habit and the most generally destructive.

Following a general treatise of the insect, its life history, habits, foods and injury an exhaustive discussion of combative measures is given. Fumigation is advised for extreme cases.

Observations on the Color Changes of the Diphenylamine Reaction, E. M. Harvey, Journal Am. Chem. Soc. 42; 1245. 1920.

The factors controlling the production of the characteristic colors of this reagent in the presence of nitrates were studied. An application of the findings was made to the microchemical detection of nitrate in apple and other plant tissue. A new formula for making up the reagent was suggested as well as a method for making the test.

Observations on the Biology of Apple Aphids, F. H. Lathrop, Jour. Econ. Ent. Vol. xiv. Oct. 1921.

Regional variations in the behavior of our apple aphids make necessary some modifications in the application of control measures.

The Cherry Fruit Fly, A. L. Lovett, Bien. Rept. Oreg. State Bd. of Hort. 1921.

A general discussion of distribution, injury, life-history, and a recommendation of sweetened poison bait in control.

European Canker on the Pacific Slope, S. M. Zeller and C. E. Owens. Phytopathology 2: 464-468. 1921. The occurrence of European Canker in Oregon and California is reported and the hosts listed. The cankers on apple and pear are described with emphasis on the distinction between the type of canker found in this region and that described from Europe.

Host Relationships of Puccinia glumarum, C. E. Owens and C. W. Hungerford. In press, Jour. Agr. Research.

Distribution of Nitrogen in the Alfalfa Seed, H. G. Miller, Jour. Amer. Chem. Soc., Vol. 43, No. 4.

Nitrogen Compounds in Alfalfa Hay, H. G. Miller, Jour. Amer. Chem. Soc. Vol. 43, No. 12.

The Physical Properties of the Commercial Arsenates of Lead, R. H. Robinson, Jour. Ind. and Eng. Chem. Vol. 19, No. 4.

Manganese in Commonly Grown Legumes, J. S. Jones and D. E. Bullis, Jour. Ind. and Eng. Chem., Vol. 13, No. 6.

The Use of Silicia Crucibles for the Determination of Potassium in Soils, J. S. Jones, and J. C. Reeder. Soil Science.

Acid Soil Studies I. A Study of the basic exchange between soil separates and salt solution, R. H. Robinson. Soil Science, Vol. II, No. 5.

Acid Soil Studies II. Changes in calcium compounds added to acid soils, R. H. Robinson and D. E. Bullis. Soil Science, Vol. II, No. 5.

Toxicity of various fractions and combinations of fractions of coal-tar creosote to wood destroying fungi, S. M. Zeller (with H. Schmitz) Jour. Ind. and Eng. Chem. 13: 621 (July 1921).

A contribution to our knowledge of Oregon Fungi, S. M. Zeller, (in press), Mycologia 14: July 1922 (25 pp).

Leucogaster and Leucophleps in North America, S. M. Zeller (with C. W. Dodge), (in press) to appear in Ann. Mo. Bot. Card.

Occurrence of Tylenchus dipsaci on Alfalfa in Oregon, M. B. McKay. Presented at the meeting of the Pac. Div. Am. Phytop. Soc., Berkeley, Calif. August 1921.

Distribution of Tylenchus dipsaci on wild strawberry in Oregon, M. B. McKay. Read before Pac. Div. Am. Phytop. Soc., Salt Lake City, June, 1922.

Thielavia basicola on water melon in Oregon, M. B. McKay. Read before Pac. Div. Am. Phytop. Soc., Salt Lake City, June, 1922.

A destructive rust on spinach (Puccinia sunitens Dietel) in the Northwest, H. P. Barss. Read before Pac. Div. Am. Phytop. Soc., Salt Lake City, June, 1922.

The Eastern Filbert blight menace, H. P. Barss. Read before Western Plant Quarantine Board, Victoria B. C. June 8, 1921. Published under the title "The protection of the filbert industry in the west," in Cal. Mo. Bul. St. Dep't. Agric., Volume 10; 250-253.

Cherry Insects and Their Control, A. L. Lovett. Better Fruit. March 1921.

Spreaders, A. L. Lovett. Oregon Grower. January, 1922.

What of the Use of Spreaders, A. L. Lovett. Better Fruit. Feb., 1922.

Prune Root-borer, F. H. Lathrop. Oregon Grower. Apr., 1922.

Sulphur in Relation to Soil, W. L. Powers, Rec. Record.

Burning Straw Ruinous, W. L. Powers. Pac. Hd., Oregonian, Oct. 4, 1920.

The Net Duty of Water, W. L. Powers, Irr. Cong. St.. Lake and Irr. Record.

Progress and Value of Soil Investigations. W. L. Powers. Pac. Hd. and Oregon Voter.

State Land Surveys Speed Reclamation. W. L. Powers, Oregonian, Feb. 21, 1921.

Tiling Investigations for White Land, W. L. Powers. Pac. Hd., Oct., 1921.

Field Moisture Capacity and Wilting Point of Soils, W. L. Powers. Soil Science.

Increasing the Duty of Water, W. L. Powers. Soil Science.

Building Drainage Ditches with Water, W. W. Johnston. Ag. Eng. Jour.

Use of Phosphorus in Oregon Soils, C. V. Ruzek. Pac. Hd.

POPULAR ARTICLES

Several hundred popular articles were published in leading Journals and magazines, several hundred in newspapers, and a large number of mimeographs were prepared and used in answering correspondence.

RESULTS OF INVESTIGATIONS UNDER WAY

Following is a brief statement of progress and results for the main investigations under way during the biennium. The reports are grouped by Departments and Branch Stations and are essentially as reported by department heads, project leaders, and branch station superintendents. Attempt is made to indicate progress during the biennium and briefly the findings on each investigation to date.

DEPARTMENT OF ANIMAL HUSBANDRY

Investigations of this department are carried on at the Central Station at Corvallis and in cooperation with the branch station at Union. Results at Union are reported under the branch station.

At Corvallis attention was again directed mainly to determining the value of the common feed stuffs, the cost of production and the factors affecting these costs.

Hogs

The Oregon Experiment Station has determined the value of nearly all of the more common hog feeds and is thereby able to give the farmer information which will enable him to feed his hogs most economically under any given conditions. We have determined quite accurately the comparative values, the amount of pork which we can produce, and the best methods of feeding such products as barley, wheat, corn, shorts, middlings, oats, hulled oats, molasses, cocoanut meal, potatoes, corn

silage, root crops, skim milk, buttermilk, whey, cabbage, fish meal, and such pastures as clover, rape and clover, drilled rape, wheat, rye, rye grass, vetch. These results have mostly been published in our bullitins and in condensed form on a little post card entitled, "Comparative Values of Pig Feeds."

Most important, we have been able to tell quite accurately the cost of pork production and the possibilities of utilizing waste under various conditions. By the utilization of waste products, Oregon can produce approximately enough pigs to meet local needs for pork and can do so at a profit, in spite of the high price of Oregon grains. We have on the other hand demonstrated that Oregon can not produce the large numbers of hogs that the packers ask us to do without demoralizing the market and without using too much expensive feed. We have, therefore, been able to hold in check the various agencies that have desired to increase hog production too far and to keep hog production down to a number that the farmer can produce cheaply and profitably. Oregon is producing about 250,000 to 300,000 hogs a year, and these hogs bring to the farmers about five to six million dollars annual income. From the standpoint of permanent investment, hogs are a minor industry, but the increase is so rapid that the annual return reaches a large figure.

We have shown that the dairy farmer who sells his cream and who raises only half his calves can very profitably raise one pig for each cow, and thereby obtain a good price for the skim milk. The grain farmer can raise one pig for each 5 to 20 acres of grain and make a good profit from the operation. Garbage is also a good source of profit to the hog man. It will require approximately the garbage from 15 people to fatten a pig, but it is often advisable to use a good deal of grain and other feeds in addition to the garbage, thus using less garbage. In this manner, one pig for each family would about utilize the waste. On this basis, Oregon, Washington, and Idaho could just about produce enough pork for local use but not enough to over-stock the market. Oregon needs around 250,000 to 275,000 hogs annually and is producing about 250,000. The shortage is made up by shipment from the Dakotas and Nebraska.

Oregon could increase her production of hogs to 325,000 or 350,000 per annum if all the waste were utilized, and could do so at a profit. We are, therefore, advocating some increase in hog production in Oregon, on the basis of the utilization of waste, as outlined above.

In an industry so sensitive to over-production or under-production as the pig industry, the value of the accurate data of the Experiment Station becomes apparent. It is our judgment that the general spread of information on pig feeding such as has been demonstrated by the Experiment Station has changed methods in Oregon quite materially during the past ten years and that the methods now in vogue are at least ten percent more efficient than those of ten years ago. This would mean on a five million dollar output a saving of $500,000. It is our judgment that on the basis of present knowledge there is a possible five percent, or 250,000, further improvement. In addition to this in Oregon there is feed material going to waste which on the basis of our experiments could be converted into pork and made to bring in from $300,000 to $500,000. This is all on the basis of information already

available. There are still many problems to solve, many possibilities for cheaper production yet unknown, and many losses which we are yet unable to eliminate.

Sheep

The work with sheep has been along the same line as with hogs, but has not been so extensive, partly because sheep are much more difficult to deal with experimentally and partly because our sheep work has been badly broken into by disease and by attacks from dogs. We have been able, however, to work out pretty well the amounts of the various kinds of pasture required for sheep and the proper rotation of pastures to provide year-long grazing. We have demonstrated that success in raising sheep in Western Oregon depends primarily upon having a long pasture season, with a minimum winter season when the feeding of grain and hay is necessary. This long pasture season depends upon having rape, clover, and other sown pastures properly to supplement the native pasture and, of course, all in turn, depends upon having an accurate knowledge of the amount of stock which a given pasture will profitably support, so that feed can be conserved for the entire season without waste on the one hand and without the necessity of extensive winter feeding on the other hand. No work with range sheep or winter fattening lambs is done at this station since that work is all done at Union where conditions are more favorable.

Horses

In our work with the cost of horse power, we have been able to show that by proper distribution of farm work throughout the year, it is possible and practical to double the amount of work done per horse per annum. Whereas the average farm horse works only one-third of the time, the horses on the Experiment Station work over sixty percent of their time, and for six to seven months of the year are busy practically one hundred percent of their time. This, of course, cuts the cost of horse power approximately one-half.

Beef Cattle

All of our work with wintering stock cattle and with fattening steers is conducted at Union. At Corvallis our only work has been with pure-breds largely along the lines of cost of production and particularly of obtaining the relative costs of growing pure-bred bulls for the range trade. We have also used our pure-bred herd in our tests to determine the palatability and value of the various silages put up by the Farm Crops Department.

DEPARTMENT OF DAIRY HUSBANDRY

Raising Calves on Milk Substitutes

This project, started during 1919-1920, was continued this year Twenty-one grade calves from one to three days old were purchased with which to carry on the investigation. One of these calves, in transit

from the Dairy barn to the Young barn, jumped out of the wagon and broke his neck, leaving 20 calves started on the trials.

Four mixtures were used as follows:

No. 1.	Mill run 100 lbs. Gr. barley 100 Gr. red clover hay 50 Oil meal 40	No. 3.	Mill run 100 lbs. Gr. barley 100 Gr. oats and vetch hay 50 Oil meal 40
No. 2.	Mill run 100 lbs. Gr. barley 100 Gr. red clover hay 50 Soy-bean meal 40	No. 4.	Mill run 100 lbs. Gr. barley 100 Gr. oats and vetch hay 50 Soy-bean meal 40

While the preliminary trial seemed to indicate that young calves could handle this ration it did not prove so satisfactory in this trial. The calves did very poorly on the start and nine of them died. Autopsy showed that the abomasum was engorged with fibrous feed that could not pass into the small intestines.

This may have been caused, to some extent, by the fact that our mill would not grind the hay especially fine.

It became necessary to cut down on the amount of the meal fed and to supplement it with milk in order to keep the calves alive.

The eleven calves which survived were on experimental feed 233 days and gained an average of 200.7 pounds in weight and 21.5 centimeters in height at the withers. They each consumed, on the average, during that time, however, 530.9 pounds of milk besides 398.7 pounds of calf meal and 319.4 pounds of hay.

The daily gain was .857 pounds and the daily growth .092 centimeter.

The calves have not had a thrifty appearance; their coats have been rough, and they have been subject to more or less bowel trouble. The heifers will be kept until freshening so as to observe any effect of their poor start in life on their production.

Silage Investigations

The third year's feeding trials with corn, oats and vetch and sunflower silage have been completed. This year, however, red clover hay was used in the basal ration in place of alfalfa, as it seemed impractical, at prevailing prices, to secure alfalfa hay.

The same difficulty was experienced, as in previous years, of getting the cows to take readily to the sunflower silage. Some of the cows ate it quite readily, but others had to be coaxed and then did not seem to relish the sunflowers. This was especially true with the Ayrshire heifer No. 431. We also had the misfortune to lose the Ayrshire heifer No. 429 just as she was starting on her final period of sunflower feeding, but her death was in no way connected with the kind of silage she was eating.

When fed oats and vetch silage, the cows produced more milk this year than with either of the other kinds, namely 586.2 pounds per cow in 30 days as against 570.6 pounds per cow on corn and 494.9 pounds per cow on sunflowers.

The following table shows the total digestible nutrients consumed per 100 pounds of milk and per pound of butter-fat for all three years and the average for each feed for the three years' trials:

	Nutrients consumed per 100 pounds milk			Nutrients consumed per 1 pound butter-fat		
	Sunflower lbs.	Oats and vetch lbs.	Corn lbs.	Sunflower lbs.	Oats and vetch lbs.	Corn lbs.
1920	79.637	90.273	93.513	20.167	24.453	25.160
1921	59.745	66.945	68.867	15.31	16.430	17.964
1922	78.740	64.118	65.203	17.95	15.232	14.814
Ave. 3 yrs.	69.645	72.180	73.842	17.264	17.977	18.666

In amount of digestible nutrients used to produce 100 pounds of milk and one pound of butter-fat this table would indicate a slight advantage for the sunflower silage, with oats and vetch a second and corn third.

It should be kept in mind, however, that this experiment was run with a constant basal ration of grain and hay and that this slight advantage might be overcome by rearranging the grain ration so as to equalize the balance with the different kinds of silage.

From the practical standpoint of securing the largest flow of milk and fat the oats and vetch seems to have a slight advantage as indicated by the following table which is an average of the three years' trials.

Kind of silage.	Daily production			Daily consumption			
	Milk lbs.	Fat %	Fat lbs.	Hay lbs.	Grain lbs.	Silage lbs.	Gain in weight lbs.
Oats and vetch	20.99	4.016	.843	9.96	7.7	30.2	.48
Corn	19.97	3.981	.795	9.9	7.6	29.04	.25
Sunflower	19.44	4.032	.784	9.9	7.4	27.0	.04

The lack of palatability seems to be the greatest handicap of the sunflower silage so far as the feeding value is concerned. No difference was apparent in the relish with which the corn and oats and vetch were eaten by the cows.

In yield per acre the oats and vetch has the lead under our farm conditions making us an average yield of 16 tons per acre. The sunflowers were a close second with 14.7 tons per acre and the corn a poor third with 8 tons per acre.

In the labor required to grow the crop under our conditions the oats and vetch has the advantage as it is seeded in the fall and needs no further attention until it is harvested in June or July, while the corn and sunflowers require spring seeding and summer cultivation. The vetch also has the advantage of being a legume and a soil builder. The silage from the oats and vetch is considerably richer in protein which would help to eliminate the purchase of so much of the high protein concentrates.

It has the further advantage of coming on at a season of the year when good silage is needed badly and allows one to get double use from his silos by filling in the summer with oats and vetch and again in the fall with corn or sunflowers or both.

In view of all of these facts it would appear that the Western Oregon dairyman is overlooking a very good thing if he does not plan an oats and vetch crop for silage.

Effect of Kind of Silage in Composition and Quality of Butter-fat

Butter was made from the milk of each group on the different kinds of silage and scored for flavors, an attempt being made to detect any feed flavors. No feed flavors were detected; however, there seemed to be a slight tendency on the part of the sunflower silage toward a tallowy body.

The chemical and physical constants for butter-fat were run on the samples of butter. The most marked difference seems to be in the Iodine Number which was in all instances higher for the sunflower butter than for the others. The average of all analyses were for sunflower butter 29.317, corn 26.965, and oats and vetch 26.247. This would indicate a larger content of Olein in the butter made from sunflower silage.

Wintering Dairy Heifers

In continuation of the work started along this line two years ago 16 heifers were divided into two groups and fed during a forty-day period during the winter. A sixty-day period was planned, but owing to the fact that very little corn was available for the silo in the place where the work was carried on the silage did not keep very well and ran out before the end of the period.

One group of heifers ranging in age from 1 to 2 years was put on oats and vetch hay and corn silage. The other group received small amounts of a grain mixture made up of 500 pounds of corn-meal, 300 pounds of mill-run, and 100 pounds of cottonseed meal in addition to the hay and silage.

The following table shows the results obtained:

	Hay consumed lbs.	Silage consumed lbs.	Grain consumed lbs.	T. D. N. consumed lbs.	Cost of feed	Initial weight lbs.	Gain lbs.
Hay and silage	3847	5740	.....	2824.9	$43.20	5529	134
Hay and silage and grain	3050	5611	660	2959.1	48.45	5237	369

Both groups refused some hay and silage showing they were getting all they would consume. Neither group put on excessive fat. This would indicate a small amount of grain as a necessity in successfully keeping dairy heifers growing well.

This experiment should be continued for several years using different kinds of silage and keeping accurate data as to growth and gains.

The work with the Abortion Disease and kindred troubles, carried on by the Veterinary Department, is of vast importance to the dairy industry of the state and the Dairy Staff are anxious to continue cooperating, in every way possible, with them in this work. Many stumbling blocks are continually appearing, but we feel that some progress is being made.

DEPARTMENT OF POULTRY HUSBANDRY

Work of the department was continued along the lines of previous years. A great deal of time and effort was directed to compilation, analyses, and publication of data and results in Station Bulletins 179 and 180, both of which have been greatly in demand.

The findings are summarized as follows:

1. Individual variation in egg production is very great, ranging in our experiments from 0 to more than 300 eggs in a year.
2. This variation does not appear to be a breed characteristic.
3. The highest individual record among the Barred Plymouth Rocks was 308 and the lowest 3 eggs. The highest White Leghorn record was 302 and the lowest 1 egg. The highest among the Oregons was 309 and the lowest 14 eggs.
4. There was apparently no decrease in variation when the flock production was increased by breeding. The range between the high and the low remains about the same.
5. The highest egg record in the original or foundation stock was 218 eggs. This has been increased to 308 as the maximum in the pedigreed, high-producing stock.
6. In a supplementary experiment in a flock of the Station's strain of Oregons, kept at the Oregon State Hospital, Salem, a high record of 330 eggs was secured with a total of 17 hens laying 300 eggs or more.
7. The pullet progeny of high-record, pedigreed stock showed a large increase in production over the unselected, low-producing foundation stock.
8. Regardless of any question of prepotency, the selection of breeding stock on the basis of high production record is a certain method of increasing production.
9. Some individuals, however, showed greater power of transmitting high fecundity than others of the same breeding.
10. Good layers were not always produced by good layers, nor were poor layers always produced by poor layers.
11. More rapid progress will be made by the breeder if he can test the breeding quality of his stock, and use for breeding those hens and males whose progeny has shown high production.
12. In a few exceptional cases, the production of the pullet progeny was higher than that of the dam and sire's dam.
13. The average production of the pullets was less than the average of the parents where the parents were selected among the highest producers, but there were individual cases where the pullet records were higher than the parents' records.
14. Breeding from the highest producers decreased the number of poor producers, but it did not decrease variability nor obviate the necessity for continuing selection of breeding stock.
15. Breeding from the highest producers showed a progressive increase in the maximum individual production, showing that the opportunity for selection was as great at the end as at the beginning of the experiment.
16. Under favorable environmental conditions, the annual record of the hen is undoubtedly the best measure of a hen's laying capacity. Where the environmental conditions are not favorable, the short-period production, monthly or bi-monthly, preferably in the season of maximum production, gives a more certain indication of inherited egg-laying capacity than the annual record.
17. There was a close relation between rate of laying, or intensity of production, and annual production. Rate of laying is within certain limits an accurate measure of egg-laying capacity.

18. Good laying capacity was indicated (1) by heavy production at the beginning of the laying year or in the fall and early winter, (2) by heavy production or high rate of laying in any one or two months of the year, (3) by heavy production at the end of the laying year. By trap-nesting for two months at the beginning of the year, or in the spring months or in the late summer and fall, the records obtained will constitute a fairly accurate basis for culling.
19. The best two-months' production is a fairly accurate basis on which to select hens of best laying capacity.
20. There was a close correlation between March and April production and annual production.
21. In the Station's experimental flocks there was a greater difference in the number of eggs laid, between the best and poorest layers in March and April than in November and December, but the percentage deviation from the mean was greater in November and December than in March and April, the months of lowest and highest production.
22. Variations in vigor and environmental conditions are the disturbing factors in the study of trap-nest records.
23. With good vigor, a hen's production may extend over a longer period than may that of a hen of the same laying capacity but without the vigor.
24. Late laying in the summer and fall did not always indicate a good layer. A hen with low rate of laying and good vigor may lay late in the summer and fall.
25. Our records show on the average a higher production in the pullet year, or first laying year, than in the second or subsequent years. There was a rather consistent decrease each year. The greatest decrease was in the production of hens with highest first-year records. Where the production was very low in the first year, there was on the average an increased production in the second year.
26. The best layers in the first year, on the average, though showing the greatest decrease in the second and third years, show better records in the second and third years than poorer layers.
27. There appears to be a correlation between rate of laying and the fat content of eggs.

Inheritance of High Egg Production

The results from the first ten years of investigation on the project were reported in Station bulletin 180. The work has been continued the past two years. Two new individuals have been produced and have made records worthy of special mention.

S. C. White Leghorn hen K 630, laid 300 eggs in the Western Washington Egg Laying Contest between Nov. 1, 1920, and Oct. 31, 1921.

Barred Plymouth Rock hen K 24, laid 324 eggs at the California Farm Bureau Egg Laying Contest between Dec. 14, 1920, and Dec. 13, 1921. This is a World's Record for the annual production of a Barred Plymouth Rock. Not only did this hen lay well in her first year but she has continued in her second without ever having stopped for longer

than seven consecutive days. June 30, 1922 was the 564th day since that on which she laid her first egg. During that time she has laid 443 eggs, or maintained an average production of 78.5 percent for that entire period. During the 1922 hatching season her eggs were found to be 95 percent fertile and gave 54 percent hatchability. The hen herself weighed exactly five pounds when weighed in December, 1921, while her eggs, when weighed in March, 1922, averaged in weight 24.60 ounces to the dozen.

Study of Type

Considerable tabulation has been done on the data collected on this subject, but it has not yet progressed to a point at which any definite conclusions may be drawn.

Early Laying Maturity a Sign of Good Laying Ability

Tabulations have been prepared on this subject and in part the results were reported in Station bulletin 180.

Relative Influence of Sire and Dam

A great deal of tabulation has been done in connection with this subject, but as yet the data are not in proper shape for conclusions and publication of the results.

Effect of Inbreeding

During the past year all data previously accumulated on this subject have been worked over. A definite project has been started carrying this work forward. Some interesting data are now being taken in the way of monthly weights of inbred chicks as compared with others that are not inbred. The work has not yet progressed far enough, however, to warrant the drawing of any definite conclusions.

Meat Qualities and Egg Production

The breeding work is still being continued along this line.

External Characteristics as an Indication of Laying Capacity.

No additional experimental work has been done on this point.

Breed Improvement

The distribution throughout the state of both hatching eggs and cockerels has continued. The demand always far exceeds the supply.

Incubation Investigations

The system of records used in the recording of incubation data has been modified somewhat during the past year, and an entirely new form added. The object of this form is to link our records on incubation with the rest of our system of records in such a way that any portion can be located instantly. This step has entailed considerable office work, but the results are gratifying as it will now be possible to proceed with the tabulation on this subject in a very systematic manner.

DEPARTMENT OF VETERINARY MEDICINE

The work of the department has again been centered upon Diseases of Breeding Cattle. Work as outlined in the Director's report for 1919-1920 has been continued.

Infectious Abortion Caused by B. Abortus (Bang)

Methods of Spread of the Disease

The feeding of infected milk to heifer calves. During the past 12 months 26 additional heifers have been used in this experiment. All these have given negative blood tests before the end of the milk feeding period. This brings the total to 92.

TABLE I.

Heifer calves fed infected milk	Negative agglutination	Positive agglutination
Previously reported	66	0
Tested 1921-22	26	0
	92	0

The breeding of negative cows and heifers to negative bulls which have served positive cows. This has been followed with the same results as reported last year, i.e., the bulls have not spread the infection.

Exposure during advanced pregnancy. Two cows well advanced in pregnancy aborted within 28 and 45 days respectively after pasture exposure.

The significance of maximum agglutinations. Maximum agglutinations have been run monthly for the past three years on about 10 to above 50 reacting cows. The following conclusions can be drawn from this work:

A single maximum agglutination is of no value in determining whether a cow will abort.

There is a slight tendency for the agglutination titer to rise beginning about the second month of pregnancy and a somewhat greater tendency for it to go up just before the termination of pregnancy. In animals with infection of long standing there is a tendency toward a drop in the agglutination titer the first month after calving.

The Relation of the Act of Abortion to the Time of the Initial Infection. Animals are most apt to abort during the pregnancy in which the initial infection is received.

TABLE II

Pregnancy after infection	1st	2d	3d	4th	5th	6th
Aborted	30	13	7	4	2	1
Calved normally	10	19	16	9	1	0

Animals infected during their first pregnancies are more apt to abort than those infected during later pregnancies.

TABLE III

Pregnancy in which infection occurred	1st	2d	3d	4th	5th	6th	7th	8th	9th
Aborted	18	7	4	1	0	0	0	0	0
Calved normally	2	2	2	1	3	0	0	0	1

The possibility of the non-functioning udder ridding itself of infection with B. abortus (Bang). Only one additional herd has been observed. This was a group of approximately 400 grade Hereford heifers. During the winter of 1920-21 it was estimated that above 60 percent of these animals aborted. They received no treatment whatever, were bred to calve in March and April, 1922, and in March it was reported that there had been no abortions. Calves were being dropped normally. There was no opportunity to make blood tests on these animals.

The habitat of B. abortus (Bang) in the cow's body. The results of investigations by other workers indicate that the organism lives only in the pregnant uterus and the udder. To determine whether there would be agglutins in the blood of animals not pregnant and possessing no udder tissue the udders of two heifers were removed by surgical procedure. One of these was bred and became pregnant. She was stabled with an aborting cow and just before pregnancy terminated her reaction changed to positive. This continued for six months, the reaction becoming less prominent each month until it is now only suspicious in the 1:50 dilution. It was very definite in 1:200 dilution in February, 1922.

The other animal was penned with abortion-infected cows and became positive up to 1:300 dilution in March, 1922. This has now dropped to 1:100 as the highest positive dilution.

The production of agglutinins has evidently ceased in the bodies of both these animals. This probably indicates there is no infection in the bodies of these cows, thus agreeing with results obtained by cultural methods by other investigators.

The possibility of eradicating abortion through testing herds, eliminating all reactors, and cleaning and disinfecting the barns. As reported last year this method is proving successful in individual herds. Plans are now under way to attempt this method of eradication on the Hermiston Irrigation Project involving some six to eight hundred cows.

The Possibility of building up abortion-free herds from abortion-infected herds. As reported previously a system similar to the Bang system of controlling tuberculosis is being tried out with two herds. All animals are tested regularly, all reactors are kept in a separate barn, and heifers from the reactors are added to the clean herd when they reach breeding age. In one small herd with five reactors there has been no spread of infection to the sound animals in 15 months. The reacting cows are breeding fairly well and calves are being raised. The owner is well pleased with results.

In December, 1920, another large herd was divided into two groups. Results to date are as follows:

TABLE IV

Non-infected cows	Pregnant heifers	Non-infected open heifers	Total
January, 1921	29	27	56
June, 1922	32	36	68
Increase in non-infected animals since January, 1921	3	9	12

The Persistence of Abortion. Where accurate records have been kept the disease has not lost its virulence in seven years. The percentages of abortions in one herd under careful observation during the past years follow:

TABLE V

	Abortions	Percent	Normal Calves	Percent	Total
1919-20	14	30.4	32	69.6	45
1920-21	10	18.8	43	81.2	53
1921-22	14	20.8	53	79.2	67

It is interesting to note that there were 12 abortions out of 26 pregnancies in the wing of the barn where only infected cows are kept. The gain in normal calves has come very largely from the non-infected cows.

Two cows have aborted five times each, one has aborted four times, and three have aborted three times.

Abortion-infected cows seem to abort with greater frequency when standing in stanchions in close proximity to other infected cows than when in box stalls. This is probably because of re-infection. Further data are being collected on this.

The Incidence of mastitis in B. abortus (Bang) infected cows. Continuing the studies reported last year there is a great deal more mastitis in the infected cows under observation than in the abortion-free cows.

TABLE VI

	Mastitis	Normal	Total
Abortion-infected cows	31	13	44
Abortion-free cows	2	25	27

Miscellaneous Agglutinations. During the past year 1478 samples of blood have been received for agglutination tests. These came from the different counties of Western Oregon. Of these 558 or 37.7 percent were positive.

The Possibility of Another Organism than B. abortus (Bang) as a Causal Agent for Abortion. During the year 1921-22 many animals not giving positive blood tests but which have aborted were found in Tillamook county. Field observations have not been followed by a diagnosis. In some instances the disturbance has resembled an infectious disturbance rather closely. It has not been possible to determine the cause of the abortions in these cattle.

Sterility in Breeding Cattle

Very little additional data on sterility have been accumulated.

Miscellaneous

Anthrax. A positive diagnosis of anthrax was made in December, 1921, from material brought to the laboratory from a herd of dairy cattle in Marion county. This was reported to both state and federal authorities and they controlled the outbreak through vaccination. It was demonstrated that the organisms can be recovered from the ear, thus making it unnecessary to open a carcass in order to secure material for examination. This is the first outbreak of anthrax to be diagnosed in the Willamette Valley.

Coccidiosis in Fowls. This disease seems to be much more prevalent than ever before. Diagnoses have been made in more than a dozen outbreaks. Coccidia have been found in large numbers in both the small intestine and the caeca. Treatment with hydrochloric acid added to the drinking water at the ratio of one part to 500 of water has apparently given good results.

Attempts at transmitting this trouble through feeding the intestines of affected fowls to sound birds were unsuccessful.

Fowl Cholera. One outbreak of fowl cholera was diagnosed in March, 1922 in a small flock near Corvallis. This is the first positive diagnosis of this disease that has been made in the state. The disease disappeared after causing a mortality of about 20 percent. It did not spread to surrounding flocks.

Salamander Poisoning in Poultry. Many reports of fowls being killed by eating salamanders have come to the department.

In these experiments the common water dog *Notophalmus torosus* was used. First mature hens were placed in pens and live salamanders were offered to them. Then killed salamanders and finally ground salamanders mixed with dry mash were kept before the birds. In no instance did the fowls eat any of the material, even when they were starved for two days. Finely ground salamander was administered to three fowls in doses of about one ounce each by means of a rubber tube passed into the crop. The birds uniformly failed to develop any symptoms of poisoning.

Since it was impossible to have the fowls eat the salamanders no further experiments were conducted.

Botulism in Poultry. The feeding of canned corn previously inoculated with *B. botulims* produced symptoms and death in fowls comparable in every way to the disturbance locally known as limberneck. It was demonstrated that flushing out the digestive tube with water has considerable curative value provided treatment is given early in the course of the disease.

The Possible Relation of Length of the Intestines to High Production in Fowls. Mr. Knowlton of the Poultry Department has begun some studies under our supervision of the length of the intestines of hens in the college flocks. It is too early to report any results.

DEPARTMENT OF FARM CROPS

VETCHES AND RELATED PLANTS

These investigations have standardized recommendaions as to varieties, time, rate, and method of seeding vetches and have demonstrated the very great importance of these plants as a forage crop.

Varietal Trials. Vetches are useful for hay, silage, soiling, green manure, and seed. Many varieties have been grown in the nursery, the rod-row and the plot trial, and the ones that have been proved economically feasible are common or Oregon vetch, *Vicia sativa*; Hungarian vetch, *Vicia pannonica*; woolly podded vetch, *Vicia dasycarpa*; hairy vetch, *Vicia villosa*; purple vetch, *Vicia atropurpurea*; and two related plants, horse beans, *(Vicia faba)* and Tangier peas *(Lathyrus tingitanus)*. These are all valuable forage plants.

Forage Vetches. Oregon vetch is the best hay and silage vetch for well drained, heavy, upland soil. Hungarian vetch is the best for the low, flat, and not very well drained land. Woolly podded vetch is hardy, makes a fair quality of forage, and adapts itself to certain sections of severe winter and for pasture. Tangier peas are primarily silage and green manure plants.

Seed Vetches. **Purple vetch,** discovered by Experiment Station investigations, was grown by farmers in the year 1920-21 with great success in the central Willamette Valley and from 1919 to 1922, in the southwest coast district, to which it seems especially adapted. It has proved an excellent seed yielder and the California demand for it is good. It is not as hardy as common, hairy, woolly podded, or Hungarian

vetch, but the western and especially the southwestern Oregon winters are usually mild enough so that it survives early fall seeding. **Hairy Vetch** and **woolly podded vetch** are hardy vetches that have produced good seed yields, in connection with the experimental work, and for which there is a large seed demand. By making use of the Station's information, at least $150,000 annually might be brought to the state by growing these vetches and selling the seed in the eastern and southeastern states where the demand is strong. **Hungarian vetch** seed is in strong demand at present, although we have nothing to indicate its development into a large market outside of the Willamette Valley. **Tangier pea** seed is in demand in California. **Oregon vetch** seed is extensively used locally and in California.

Hungarian vetch. This vetch deserves especial mention, as it is adapted to very wet, unfavorable conditions, and is a good yielder of hay, silage, and seed. It shatters seed less readily than most of the other vetches. It is very resistant to attack from aphis, and is a very good bee plant. Sixty to seventy acres were planted in the fall of 1921, and the seed will be distributed widely in 1922.

Tangier Peas. Tangier peas have continued to yield well for silage purposes, coming up to 24.28 tons per acre. They make good silage which is readily consumed by livestock. Tangier peas are not as hardy as Hungarian vetch or common vetch, and were largely killed out during the winter of 1921-22. This was the first heavy winter killing with early seeded Tangier peas in fourteen years. They will be again multiplied in 1923, as they appear to be a very valuable forage and green manure crop.

Horse Beans. Horse beans have continued to develop into a successful crop, and have yielded up to forty bushels of threshed seed an acre. They also offer promise as a supporting crop in connection with vetches for silage purposes. They are best adapted to soils that are well drained, mellow and reasonably rich, and special inoculation is necessary for success with them. They should find a place on many Western Oregon dairy farms for silage combinations and as a grain crop.

Cultural Trials. Cultural trials indicate that for seed purposes it is usually best to grow purple vetch, Tangier peas and Hungarian vetch, hairy vetch and woolly podded vetch alone, without a supporting or companion crop. They should be planted medium early in the fall to get sufficently established to withstand the winter. An excessively rank growth from thick early planting is somewhat dangerous because of the spread of the stem rot. On the other hand, a weak growth resulting from late seeding and late development may not survive the winter.

A sixty- to eighty-pound seeding of common, purple, and Hungarian vetch is very satisfactory under most conditions for seed, and a similar amount, with forty pounds of oats, is very satisfactory for other than seed purposes.

Spring planting is not satisfactory, and if done at all must be very early, usually before March 1.

Vetch Rotation. The growing of vetch in rotation with other crops has proved very good for the other crops, in that yields of wheat

have substantially increased. There has been a slight increase in the yield of corn, and an increase from the original yield of oats. Yields of potatoes appeared to decline, although the rotation is too short for potatoes, when the diseases of that crop are considered. Vetch grown continuously for hay purposes is holding up its yield. The yield of seed appears to decline, although there are not enough plots to make conclusions positive on the point.

Perennial Vetches. Numerous perennial vetches are being tried, although none have proved feasible for recommendation.

Breeding Work. A study of the pollination habit of vetches indicates that they are largely self-fertile. Work in hybridization has not accomplished much. Some field selections show more promise.

RED CLOVER

Varietial Trials. Several varieties of red clover were tried in the nursery row, and field plantings were made of seed from Oregon, North Dakota, South Dakota, Ohio, and Italy. The hay yields show a difference of as much as three-fourths ton an acre, and the seed yields nearly one bushel an acre. The second winter showed a survival of Oregon, North Dakota, Ohio, and one lot of Italian seed to be better than the other Italian and the South Dakota lots.

It is probable that clover field inspection for certification should be undertaken under Western Oregon conditions.

Cultural trials. Red clover has been seeded with four winter cereals and alone in the fall, with practically uniform failures due to heaving out in the winter months. We recommend against seeding red clover in the fall. It has also been seeded alone in February and with four fall-sown cereals, giving most favorable results with seeding alone and with barley and wheat. Usually the clover seeded alone presents the best appearance, but the subsequent yield is usually not above that seeded with barley or wheat; consequently, it is a loss to sow the clover alone where it is possible to secure equally good stands by using barley or wheat as a nurse crop. Less than twelve pounds an acre of clover seed usually reduces the stand. April or May seeding of red clover alone is satisfactory and desirable on run-down land or where it is difficult to get a stand.

Fertilizer Results. A spring application of land-plaster, sulfur, and lime, as compared with no treatment—the fertilizer being applied shortly after the clover was seeded—gave a pronouncedly favorable result for the use of land-plaster, although no results in securing a better stand were noted following the use of either lime or sulfur. It is thought that the sulfur did not become available in time.

Establishing Clover on Run-down Land. This experiment is very much needed, as clover appears to be the key to the rejuvenation of many Western Oregon soils.

Breeding. A few clover selections have been and are being made. Especial problems are:

1. To develop a corolla having tube short enough so that honey bees may cause tripping.
2. A variety resistant to the clover root borer.
3. A variety resistant to the stem rot.
4. Varieties suited to soils of different degress of acidity and moisture.

SWEET CLOVER

Varietal Trials. Yellow and white flowering biennial sweet clover and the annual white sweet clover, sometimes called Hubam clover, have been tried out, and the results indicate that no one of these is as valuable as red clover or vetch for Western Oregon purposes. The white flowering biennial sweet clover and the annual sweet clover appear quite susceptible to the disease, stem rot.

BUR CLOVER

Bur clover is being tried in pastures on dry hill land and is demonstrating its ability to reseed itself and maintain itself under rather heavily pastured conditions.

ALFALFA

Grimm alfalfa has shown its ability to survive on the river-bottom land to better advantage than the strains of common planted alongside. It appears to be not seriously affected by the disease, stem rot. Alfalfa out-yields red clover on the river-bottom land.

SOY-BEANS

Inoculation is very necessary for this crop. The experimental work is progressing along this line and early varieties are necessary. Because of the lateness in maturing and danger from early fall rain, the crop may not become generally useful as a seed crop, although it does offer promise for silage and hog pasture on some warm soils.

Manchu, Mandarin, Black Eyebrow, and Ito San seem best for forage, and Ogemow and Chernie are best for seed purposes.

MISCELLANEOUS LEGUMES

Ladino Clover. Ladino clover is being tried out. It makes a very rank growth of pasture, and promises considerable success.

Numerous other leguminous plants have been and are in trial, but without showing sufficient promise to warrant mention at this time.

GRASSES

Grasses are being grown to demonstrate their usefulness for hay, pasture, lawn, and soil binding purposes and their possibilities and productiveness as a cash seed crop.

Hay Grasses. Timothy, because of its rather late maturing habit and cheapness of seed, is probably the best of the hay grasses for soils that are reasonably moist and fairly well supplied with organic matter.

The rye grasses, English and Italian, are excellently adapted to soils that are heavy and not very well drained, where a short-lived grass is desired. Reed canary grass is an excellent hay grass for conditions that are somewhat moist and probably for conditions that may not have an excess of moisture.

Tall oat grass and orchard grass, while producing an excellent forage growth, reach the hay stage too early in the season to be desirable for market hay purposes.

Seed Production. Various grasses tried for seed production have given very good yields. Kentucky bluegrass, through four years, has varied from 200 to 256 pounds of seed an acre; timothy from 345 pounds to 470 pounds of seed an acre; English rye grass from 420 to 615 pounds an acre through two years; orchard grass 240 pounds, tall oat grass 320 pounds, meadow fescue 390 pounds an acre. Annually there is shipped into the Pacific Northwest several hundred thousand dollars' worth of grass seed which can, with profit, be grown in Western Oregon.

Pasture Mixtures. A pasture mixture seeded on the Calvin Ingle hill has been growing since 1918 and has shown excellent survival. Grasses that appear best suited to the conditions are English rye grass, orchard grass, tall oat grass, meadow fescue, Kentucky bluegrass, Bur clover, red clover, and white clover. The Station findings on pasture grasses are being very widely distributed by correspondence and through newspaper articles.

SPECIAL GRASSES

Reed Canary Grass. Reed Canary grass is a grass that is especially adapted to somewhat moist, rich soils. It is hardy, produces a good yield of forage, but has an objection in that the seed is rather scarce and hard to secure. Varieties of this grass can be worked out.

Harding Grass. This is a much exploited grass that does not appear to be as hardy or as good a yielder as Reed canary grass, to which it is related.

Miscellaneous Grasses. Several rank growing, tropical grasses have been advocated, but none of them have proved worth while under Oregon conditions.

HAY STORAGE

Winter Hay Gain. Bales of hay, properly protected with burlap, show substantial increases in weight as the winter progresses through March; then declines set in as warm, dry weather occurs and the bales come back to more nearly their original weight. The total gain may amount to from 100 to 150 pounds per ton. This has a very important bearing on the problem of storing and marketing hay.

SILAGE EXPERIMENTS

Numerous lots of silage have been stored in the six-ton silos and also in trial silos and have shown that satisfactory silage may be made from many plants. Tangier peas, Hungarian vetch, horse beans, common vetch and oats, velvet grass, Canada thistles, sunflowers, corn, corn and sunflowers, rain-damaged red clover and alfalfa, vetch and barley, arti-

choke tops, navy bean straw, soy-bean straw, Reed canary grass and sweet clover all made very satisfactory silage. Especial work needs to be carried out with reference to the relation of water content to the keeping of the silage.

RAPE

Seed Production. Dwarf Essex rape, imported from England, has been grown. This crop produces up to one thousand pounds of seed an acre. It offers promise as a cash crop for moderate-sized plantings.

MISCELLANEOUS EXPERIMENTS

Freaks and Fakes. Numerous plants are exploited by individuals and organizations claiming remarkable forage value and many other useful points. Many of these highly advertised plants have been tried out and have proved not worth while for Oregon agriculture. Among them may be listed Eureka clover or Giant knot-weed, Rhodes grass, and Vasey grass.

CEREAL INVESTIGATIONS

Winter Wheat

Varietal Trials. Twenty-two varieties of wheat were included in this trial, and white winter again leads in productiveness. Other good varieties, fall seeded, are Foise, Blue Chaff Club, and Rink.

Cultural and Tillage Trials. An extensive trial of winter and spring wheat plantings on dry and wet plowed land, early and late spring plowed land, and different time and rate of seeding was started in the fall of 1921.

Breeding and Nursery Work. A large classification nursery, including all of the commercial varieties of the United States, together with a large breeding nursery, including many selections from plots and from fields of both Eastern and Western Oregon, was grown and many selections were made for further multiplication. Some of these have been included in plot trials and look like good yielders.

Spring Wheat

Varietal Trials. Sixteen spring wheat varieties were grown. Those leading in production are Huston, Foise, Mexican Blue-stem, and Blue Chaff Club. Minnesota Wonder, really not a variety but a mixture of three of them, also made a good yield.

Cultural Trials. Very little regularly organized cultural work has been under way, but it has developed generally that early planting of the spring cereals is very necessary to secure reasonably good yields, and that fall planting at the right time is very much better than even the earlier spring planting.

Oats

Varietal Trials. A limited varietal trial shows Victory to be the best yielding variety and Three-grain to be another very good yielder.

A rather extensive oat nursery is being grown.

Corn Experiments

It was necessary to drop the corn experiments because of insufficient land and funds.

Flax Experiments

These were also discontinued because of insufficient land and funds to carry on the work. The Pacific Coast district is in an excellent position to produce flax to a very great advantage, because of climatic conditions favoring the crop, its adaptability to cropping systems for Oregon, and the apparent ability of the crop to grow without as much disease as prevails in some other districts. The flax trials should be carried out on an extensive basis at the earliest opportunity.

Miscellaneous Experiments

Copper carbonate has been tried on wheat with very good results in the control of smut. Breeding work for special purposes with wheat, rye, and wheat-rye hybrids is being conducted.

POTATO EXPERIMENTS

Experimental work with potatoes is difficult and results are often seriously affected by the necessity for standardizing lots of seed before they may properly enter into any trial. In other words, lots of potatoes secured from different sources and put into trial usually are so very different in their disease content that comparative results are practically worthless, in so far as varieties are concerned, until they have been brought to a uniform basis. In other words, twenty lots of Burbank potatoes bought from the best available sources may not be typical, since so many of them vary to such a pronounced extent in the productiveness due to disease.

Varietal Trials

The varietal trials show the superiority of several varieties, including Scotch Rural, Snow, Pacific White Rose, all round or half-round varieties, and three strains of Burbanks. The highest yielder was Scotch Rural, followed by Snow, and the lowest of the six was the Pacific White Rose. The yields varied from 150 bushels of marketable potatoes up to 230 bushels per acre. In total yields the lowest was Burbank, with 194 bushels. and the highest was Scotch Rural with 299 bushels.

Cultural Trials

Ridge Versus Flat Culture. Results of the one-year trial are forty bushels an acre in favor of flat culture.

Spacing Experiments Using One-and-a-Half- to Two-Ounce Seed. Results are favorable to having the rows as close as thirty inches and the plants in the row rather close, twelve inches apart.

Using twenty bushels of seed per acre, cut into one-, two-, and three-ounce pieces respectively, resulted in larger yields from the smaller pieces planted closely.

Size of Seed. Results are favorable to pieces weighing one-and-a-half to two-and-a-half ounces rather than for smaller or larger sized pieces.

The most economical size of piece all round was the one-and-a-half ounce piece.

Manner of Cutting Seed Potatoes. Plots planted to one-and-a-half ounce whole blossom-end pieces yielded 27 bushels an acre more of marketable potatoes than similar sized split blossom-end pieces. Where a lot of potatoes had been divided into two, and one part cut to save the whole blossom-end piece and the other had been cut in the usual method of splitting through the blossom-end, the results were exactly fifteen bushels an acre of marketable potatoes in favor of cutting the blossom-end off in one piece.

Time of Planting. The yields showed a progressive decline from the early planting made on May 7 to the late planting of June 24, the difference being 169.5 bushels in favor of planting early.

Depth of Planting. There was a difference of 8.6 bushels an acre in favor of 5½-inch planting rather than 3-inch planting.

Fertilizers on Potatoes. Land-plaster applied to the cut seed made 3.2 bushels an acre increase in yield of marketable potatoes. Especially in years of slow germination it prevents rotting of cut seed pieces in the soil and makes better stands and yields.

Storage Experiments

Storage experiments in pits have shown the very great necessity for thorough ventilation, and they have also shown that there is considerable shrinkage and loss even under well ventilated conditions. The storage in pits rather indicates that a better method, such as well ventilated storage houses, must be made use of if potato storage is to be economical.

MISCELLANEOUS SERVICE

The staff members of the Farm Crops Department have put on exhibits at a number of shows, showing the Experiment Station work for here and elsewhere. An exhibit was put on at the Grain Show at Pendleton, at the State Fair, and at the Land Show at Portland. More than one hundred days were spent in the field on Extension work by Experiment Station Staff members the past year alone, and in addition to that a considerable number of conferences were held with Extension Staff members here at the institution.

Letters were written, largely in answer to inquiries by farmers and extension field workers, and purity, germination, and examination tests were made on samples of seed sent into the Seed Laboratory during the past year.

DEPARTMENT OF SOILS

The development and preservation of the soil and water resources of Oregon constitute our greatest material problem. Oregon soil investigations are conducted under a special biennial appropriation amounting to only $7,500 a year, which must be made to care for soil surveys, drainage, irrigation, and soil fertility investigations. All field and laboratory experiments of the Soils Department at Corvallis are maintained by this fund. It must also care for the field agents and the work on

the sulfur experiment field at Medford and alkali land reclamation experiment field at Vale. About $2,000 a year is required from this fund to carry on detailed soil surveys, according to agreement with the United States Bureau of Soils. Nearly $1,000 a year is needed for publications. Also some twenty cooperative field fertilizer experiments with different soil types are being maintained by this department.

In addition to the cooperation of the United States Bureau of Soils some cooperation has been obtained with the United States Bureau of Public Roads, Branch Experiment Stations, and a number of farmers.

SOIL FERTILITY INVESTIGATIONS

Fertility Rotations. A four-year rotation clover, grain, potatoes, and beets, vs. alfalfa, on the irrigation plots has gone through 14 seasons. The winter grain, unirrigated, used as a nurse crop in the rotation, promises somewhat better yields on the irrigated plots than on the one that has been dry-farmed for the 14-year period. Results are definitely in favor of the irrigation, which has not injured the land, due to the increased root growth as well as top growth and accumulation of organic matter as the result of irrigation.

A three-year rotation of grain, alsike clover, and beans is closing the third three-year rotation. In this experiment irrigation, rotation, and manure has doubled the yield of beans in irrigated experiments as compared to those grown continuously, the average yield being 9 bushels and 18 bushels an acre. Beginning with a yield of about 12 bushels an acre at the start, the continuously cropped plot has dropped to a yield of 6 bushels and the irrigated, manured, and rotated plots increased to a 22-bushel yield the past season. As compared with continuous cropping the gain in net profit from irrigation and rotation has been $14.09 and from irrigation, rotation, and manure $23.02. The rainfall-farmed plots gave an increase profit of $8.82 from rotation, $9.71 from rotation and manure. Irrigation, rotation, and manure has reduced the water requirement to 1425 pounds, where with continuous cropping the water requirement was 2909 pounds. In other words, this soil building treatment has reduced the water requirement one-half.

Thirty-two rotations started on 92 plots in 1915 are now giving very definite differences. Where manure, clover, or lime has been followed with grain the yield of winter barley just cut will run about 40 bushels an acre, while the yield of plots continuously cropped to grain will be about 25 bushels an acre.

The rotation experiment including grain, clover, and corn at Medford soil experiment field is closing the first three-year rotation this season. One-half of these plots is manured, each crop being grown on one plot continuously as a check. The section manured is beginning to show its influence on the growth of crops and water requirement. Other correlated rotations are under way at the branch experiment stations.

Fertilizer Experiments. Fairly complete fertilizer trials are now in progress on nearly a score of different soil types in the state. A new systematic experiment is planned for Willamette silty clay loam on the Home Station with enough series of plots so that each crop used in a good crop rotation can be represented each year on one range. Additional cooperative fertilizer experiments are needed on a few other

important soil types of the Valley and should be started promptly. About 300,000 dollars is expended annually in the state for fertilizers, and it is estimated that one-third of the amount invested annually in fertilizers is wasted by improper use. In some of the older trials, none of the treatments employed have proved profitable.

Successful use of fertilizers depends on their cost and the value of crop increase secured from them. Certain fertilizers for given soils have proved profitable, and their use as a farm practice is recommended.

Phosphorus. Superphosphate has proved beneficial and profitable on red hill soils of Western Oregon, on the warm, drained land of the Valley floor, and on the creek bottoms in the lower Willamette Valley. It is now being used commercially on about 20,000 acres; its use is being extended, and fertilizer experiments and soil analyses indicate that it will be helpful on about one-half million acres of red hill lands in the more humid sections of this state. Certain acid marsh soils show an indication of benefit from application of available phosphate; granitic soils, and some stream bottom soils in Southern Oregon respond well to phosphate application; sedimentary soils of the lake region are below average in phosphorus, as shown by analyses in connection with feasibility surveys, and fertilizer experiments indicate that phosphate will be of value for reinforcing manure in that section. It is estimated that phosphate has given a 25-percent increase in the 20,000 acres on which it was applied last season.

Studies are being continued on the availability and utilization of phosphorus in soils of high iron content, and lime, sulfur, manure and other fertilizers are being used in these tests. Field and pot experiments have been carried through two seasons and a large number of phosphate determinations have been made. These studies are being made by Professor C. V. Ruzek, who describes the process of these experiments as follows:

"Acid phosphate alone and in combination with barnyard manure gave larger increases in yield than rock phosphate alone or rock phosphate and manure.

"Lime did not aid in making rock phosphate more available but organic matter and sulfur did. This was shown by increased crop yields and by analysis for soluble phosphates.

"Rock phosphate when composted with sulfur and manure gives the largest increase in soluble phosphates."

Sulfur. The Medford experiment field started by Reimer in 1914 is still being maintained by the Soils Department to learn the duration of the sulfur treatment and the cumulative effects of heavy applications of sulfur from long-time experiments. Additional plots have been arranged to study the value of sulfur, phosphorus, and manure in making available phosphorus and sulfur for maintaining soil productiveness. Duty-of-water experiments as influenced by these things have been added. The experiments are in a field having been brought under irrigation. An application of 100 pounds of sulfur appears to be sufficient for about four years as an average. Repeated 500-pound applications of sulfur on alfalfa land of neutral reaction have caused only the slightest acidity as judged by different acidity tests. If crops and drainage remove sulfates, this tends to offset acidity accumulation. It is becoming more

evident that phosphorus as well as sulfur will need to be supplied to this antelope clay adobe soil.

Most of the alfalfa-producing soils have been tested out, and it has been found that about 100,000 acres of alfalfa land in Oregon can be increased in annual yield by at least a ton an acre, if a hundred pounds of sulfur is applied to the land once in four years.

A study of the functions of sulfur in relation to soil has been made a special investigational project.

Analyses of rainfall and percolate from lysimeters at Corvallis by the Station Chemist show that the sulfur received in rainfall is only four or five pounds a year, while that carried out in the percolate is about forty pounds to the acre a year or ten times as much.

Analyses of soil in connection with the detailed soil survey and feasibility survey show that the heavy soils in the Valley floor contain only five to six hundred pounds of sulfur in the plowed surface of an acre, and many of the red hill soils and the irrigated lands contain only two or three hundred pounds. Field fertilizer experiments on three red hill soils have given marked increases from the application of sulfur.

Pot tests have shown that a little sulfur or sulfate stimulates the formation of nitrate in the early season and may help explain why land-plaster has been generally used on legumes in this Valley for a generation.

New field experiments include the use of sulfur in connection with raw rock phosphate, manure and lime in combinations. Results show certain sulfur combinations to aid liberation of phosphorus. In the light of these developments part of the increase obtained from superphosphate is probably due to the sulfur content. It is believed that until lime can be more readily and generally used in the red hill section, the safer forms of material for replenishing the supply of sulfur in those soils will be acid phosphate, gypsum, and stable manure. There may be cases, however, where initial applications of sulfur will be all that will be needed. As such it is of value as a starter for clover.

Sulfur oxidized this spring, 1922, began to improve the color of grain on Carlton silty clay loam in three weeks from the time of application. The first striking increase in grain growth from sulfur has been obtained on this hill soil where a generation of farming may have reduced the limited initial supply of this element. The oat crop removes several pounds of sulfur an acre. Results are tabulated and material is ready for a bulletin covering Oregon Sulfur Investigations.

Potash. Some increases have been secured from the use of potash on the Klamath marshes. It has doubled the onion yields on Lake Labish, where soil analyses show that the soil contains only 8,000 pounds of potash in the plowed surface of an acre. Chemical analyses of Willamette Valley soils by the Station Chemist, from samples collected in connection with the detailed soil survey, show that most soils in the Valley contain twenty-five to forty thousand pounds of potash in the plowed surface of an acre, an almost inexhaustible supply, but the use of farm manure and clover in rotation will help liberate sufficient quantities to meet farm needs.

Residual soils in the Deschutes Basin are somewhat below average in this element, and complete fertilizer experiments, extending through

several seasons, including special studies of this matter, show that potassium sulfate has given the greatest profit an acre of any fertilizer used. These trials included potatoes, which are a fair cash crop. The sulfate form of potash is less apt to aggravate alkali trouble, and the sulfur is of value on these lands, particularly with legumes.

Nitrogen. The nitrogen content of Willamette Valley soils thus far analyzed runs two to three thousand pounds to the plowed surface of an acre, whereas the leading corn belt soil runs six to eight thousand pounds of nitrogen. Nitrate fertilizers have proved helpful where legume sod could not be secured for growing cash crops. The use of legumes is regarded as a more constructive and profitable treatment than the application of commercial nitrates, except as a starter, wherever rainfall or irrigation make it possible to secure this element in inexhaustible supply from the air by means of nitrifying bacteria and legumes. A little gypsum appears to aid nitrification early in the season after leaching of winter rains has removed available nitrogen.

Soil Acidity and Liming. An acidity survey is being made in connection with the soil survey, and naturally-drained soils in the Valley and stream bottoms show ½ to 1½ tons lime requirement, wet soils after drainage need 1½ to 2 tons according to acidity, and hill lands give a lime requirement of 1½ to 3 tons.

Lime is included in Western Oregon fertilizer trials. Response to lime corresponds fairly well to acidity found.

Ground limestone has been furnished by the state lime plant to the amount of about three thousand tons. Recently the plant was reopened with prospect for orders of at least an additional thousand tons. This material is needed to correct soil acidity in the more humid sections, particularly in the lower Valley and Coast sections, and the red hill soils which are distinctly acid. Lime may be expected to benefit soils known to be acid, or which possess only a medium acidity or are heavy in texture, particularly where such legumes as alfalfa or clover are to be grown. On the Willamette silty clay loam of the Home Station, a ton and a half of hydrated lime, applied once in three years, has given a crop increase in the third rotation of $15.30 value, where the rotation is grain, clover, and corn. The yield at the present season in this limed plot will undoubtedly be as high as for any of the fertilizer treatments. On an adjoining plot, heavy application of lime this season gave from 12 to 15 bushels increase in yield of winter barley. This soil was only moderately acid (1 to 1½ ton lime requirement), has fairly good natural drainage, and gives only moderate response from lime.

The imperfectly drained areas of gray and gray-brown soil in the Valley are more highly acid and give a higher increase from lime. The past year forty-five hundredths of a ton increase of clover was obtained on tiled white land from the use of lime. From lime and manure nine-tenths of a ton increase was secured. Good, visible results are in evidence on the second crop year of clover now present. A car of state lime was purchased last fall to renew treatments and extend trials. Liming experiments are now under way on Willamette, Dayton, Cove, Carlton, Amity, Cascade, and Melbourne soils.

A new experiment is planned to test the relation of ground limestone to acidity, fertility, soil, and type of crop, using chiefly Willamette silty clay loam with legumes represented each year of the rotation. Lime

is more necessary on the red hill soils which are distinctly acid. Many of these soils have been grain farmed for a generation and are badly in need of clover, but lime is often necessary to establish it. It, therefore, becomes essential to the establishment of permanent, economical systems of agriculture.

Organic Manures. A project is under way to determine the supply and best methods of increasing and maintaining organic matter in Oregon soils.

Manures used in the soil experiment field have returned a profit of $2.50 to $10.00 a ton. Crop residues are employed in several of the rotation experiments and are beginning to show definite benefit. The use of straw, disked into the land, is being studied in connection with experiments on the use and value of manure. The use of winter cover crops has been found very beneficial in adding humus and nitrogen and improving the tilth and moisture-containing capacity of the heavy soil. Rye and sweet clover are being employed in alkali-land reclamation experiments to afford pasture and green manure, and to improve soil structure. Nearly all the land in Oregon is benefited by increase in organic matter. Barnyard manure and legumes are to be preferred, largely due to their nitrate content. Crop residues and organic manures should be returned to the land in a moist decaying condition in order to work them promptly into active form, thoroughly incorporated in the soil.

SOIL SURVEY

In cooperation with the United States Bureau of Soils, field work for the detailed soil survey of Benton county and also Clackamas county has been completed and within this season the Polk county area will have been mapped. Soil Survey reports unpublished have been completed by field workers covering Washington county, Josephine county, Benton county, and Clackamas county. Mapping of Linn county has been started.

With the completion of Polk county, there will have been surveyed, not including Linn, 2,696,795 acres, including all of Yamhill, Washington, Multnomah, Benton, Clackamas and Polk counties excepting the national forest areas. Josephine county was completed in 1919, making a total area of 3,188,525 acres mapped in detail. There remain to be mapped in the Willamette Valley, Linn, Marion, and Lane counties, with a total area of 2,264,176 acres excluding forest reserves.

These surveys are recorded on a map with a scale of 1 inch to the mile, each soil type being represented in the different colors; all important landmarks are shown on the base map used. Official samples of each type were collected for submission to the Station Chemist for analyses, so that this work lays the foundation for the development of permanent systems of soil management. It serves as an invoice to the agricultural resources and forms a basis for consistent soil investigations.

Feasibility Surveys. Preliminary feasibility soil and agricultural surveys have been made during the biennium of six irrigation projects, including 428,300 acres, and of 27 drainage projects, including 167,500 acres. A total of over 3,000,000 acres has been thus mapped during the past few years and 1¼ million of this has been organized for reclamation

and nearly $18,000,000 of bonds voted with about $7,000,000 sold. These feasibility surveys establish the merits of reclamation for feasible projects, help to cull out the less desirable lands and shape them up in the most desirable way from the agricultural standpoint. All the irrigation projects examined during the biennium have been organized into irrigation districts; all but one have been financed, and construction work is well under way in most cases. At least five of the drainage projects have been organized and are in various stages of construction. Collectively, over 150,000 acres of land is being reclaimed and will be doubled in production thereby.

Assistance has been given in designing a large number of tile systems, individual pumping plants, and distribution systems as Extension work but based on Station results. Some 350 farm reclamation systems serving about 20,000 acres have been designed during the past few years.

An important feature of the feasibility surveys has been the development of an outlet system for the wet soil areas of the Willamette Valley in cooperation with the United States Bureau of Public Roads. Field data were obtained on fifteen new projects in connection with this work. These data, together with data at hand from previous feasibility surveys on fifteen other projects with a total area of approximately 200,000 acres, give the preliminary outlet plans for about all the wet areas in the Willamette Valley of more than one or two thousand acres which will require outlet ditches. This preliminary survey shows the relation of one project to another and indicates the ditches that will ultimately be needed. It also shows where large areas or where separate units will be most practicable. The cost of providing outlet ditches to these areas so that individuals can tile out their land, will average not over $10 an acre and will involve a total investment of about $2,000,000. A further investment of $15,000,000 to $25,000,000 will be required to tile out the three-quarter million acres of wet farm land in the Valley, two-thirds of which now has fair outlet facilities. Practically all of the wet lands in the Valley are found feasible of reclamation and would pay a better rate of interest on the total investment as fast as reclaimed. Drainage will be an important chapter in a report on the management of Willamette Valley soils, when prepared.

Drainage and Improvement of Wet Lands. Three important farm drainage experiments are under way. The first is a study of the water table and outflow in tiled white land and the effects of clover, lime, and manure in aiding percolation in this field and in drainage gauges or lysimeter tanks similarly treated. Lime and manure are proving very beneficial in connection with the improvement of this soil.

The second experiment is in tiling tide land, proper distance apart and capacity for tile lines as judged by water table, outflow, and yield, all being studied in cooperation with the Branch Experiment Station at Astoria.

The third drainage experiment is located on a ten-acre tract near Vale in Malheur Valley, where a deep outlet drain has been sluiced at a very low cost and the land has been cleared and checked for irrigation, and divided into plots to observe the value of the different treatments as an aid in the laundering out of the alkali and the restoration of favorable soil structure in this land. Sulfate has been very promising for

accomplishing these purposes and the application of 500 pounds of sulfur enabled 65 percent of the total alkali to be removed from the seven-foot stratum of soil during the first season and 200 pounds gypsum and manure enabled 60 percent to be removed. A fair stand of rye and sweet clover has been obtained on some plots receiving the best treatment. The sluicing work was first carried out in connection with this experiment and that was the first deep drain of the kind to be sluiced. Later Mr. Purvis, a director of a local drainage district, perfected a tool for scarifying the soil to facilitate sluicing. Sluicing has saved the southeast unit drainage district $25,000 in the construction of drainage.

Duty of Water Investigations. Irrigation Farming investigations are centered around duty of water. Duty of water investigations have been continued on the experiment fields at Corvallis, Hermiston, Burns, and Medford. Due to lack of funds trials were dropped in Deschutes and Klamath basins, while a little duty of water has been added near Vale. Irrigation gave 500 percent increase in crops on many adobe soils, where farmers questioned the feasibility of irrigation.

Results from twelve years of experiments as to the highest possible duty of water under modern methods of irrigation farming, based on the water requirements of crops giving the highest yields per acre, have been reported. Based upon this information, it takes three inches of water to produce one hundred bushels of potatoes, five and one-quarter inches to produce one ton of hay; the duty of water is not likely, therefore, to be less than 15 or 18 inches for a three-ton yield or 30 or 36 inches for a six-ton alfalfa yield. Since meadows occupy over half the area under irrigation in the open country, it takes twice as much water as the annual crop, or one and three-quarters in working out an average duty. Most of the duty-of-water data on alfalfa have been assembled and reported in bulletin form. Duty-of-water studies extend over a period of thirteen years at Corvallis, seven years at Burns Branch Station, four years in the Deschutes Valley, and seven years at Hermiston Branch Station.

Soil Correction Trials. Soil correction trials with "white land" and "black sticky" have been continued. Applications of lime and manure, gypsum, green manure, sulfur, and phosphates have tended to increase yields. Quicklime and manure seem to aid in improvement in black sticky soil. Experiments on white land developed the information that the use of manure, legumes, deep plowing, and some leveling and the use of lime improve the condition of this land and facilitate drainage, so that tiling may be more highly successful and profitable.

Tillage and Soil Moisture Studies. There is more crop shortage in the state due to improper moisture condition than any other thing.

Soil moisture studies were continued in connection with the irrigation and drainage experiments and dry-farming at branch stations.

Cultivation of furrows without leveling the surface between irrigation has proved unprofitable at the Home Station. In various parts of the state tests have been made of cutting off weed growth at the surface as against a cultivated soil mulch. On some soils the practice of cutting weeds and not establishing a mulch is impracticable, and generally a good, crumby soil mulch has proved more effective in conserving moisture and liberating plant food.

The effect of manure, crop rotation, and fertilizers on irrigation requirement has been found important. Irrigation of legumes tends to make more root growth and build up water capacity, and this in turn reduces the water requirement. A difference has been found in the wilting point of different crops. Duty-of-water studies need to be extended, as the highest productive value of water can only be realized when the duty-of-water is established, based on the needs of crops and the percentage of different types of crops and soils.

DEPARTMENT OF AGRICULTURAL CHEMISTRY

Relation of Sulfur to Soil Fertility and Plant Composition

Adams Fund Project No. 26, "The Relation of Sulfur to Soil Fertility and Plant Composition," as originally planned has three sections. Two papers have been published by Miller on results secured from work undertaken "to determine whether the sulfates act directly as plant food in causing increased growth." More work in that very definite field ought to be undertaken. Inadequate greenhouse facilities rather forced the conclusion of work in this section for the time being.

The second section concerns itself with "the effect of sulfates on the composition of plants." Miller published one paper during the year from results of preliminary work. His is pioneer work in this field. The proteins of legume seeds lend themselves to comparatively easy identification; not so those of the vegetative portion of legumes. Miller has isolated what seems to be a protein from alfalfa hay and finds that it is not the same as the predominating proteins of alfalfa seed. Individual proteins in the vegetative portions of legumes have to be isolated and methods for their examination thoroughly worked out before one can hope to get at the precise influence exercised by sulfur on plant composition. Sulfur enters into the structure of the protein molecule, but whether the proportion is increased over a certain fixed amount when extra amounts are used in the form of fertilizers can be told only by such work as Miller has initiated here.

Secton 3, which has to do with "the effect of sulfur and sulfates on insoluble soil minerals," has not yet been investigated.

Physical and Chemical Properties of Insecticides

Present-day manufacturing processes apparently yield all that is to be desired chemically in the way of insecticides. We have come to realize that the efficiency of insecticides (arsenates of lead more particularly) is dependent in a large measure upon certain physical properties they may gain in the processes of manufacture or may have imparted to them by the addition of deflocculents or spreaders. In order to help put the use of spreader on a thoroughly scientific basis Robinson has determined by physical-chemical methods the factors which give effectiveness to certain substances proposed for use as spreaders. He finds it possible to predict with accuracy the relative value of a number of substances which are likely to be tried out by the manufacturers of insecticides. The more prominent ones at present are: miscible oils, soaps, calcium caseinate, starches, proteins, and plant extracts. His work will unquestionably influence very markedly the practice of manufacturers in the field of insecticides. This work is done under Adams Project No. 10, amended to include physical as well as chemical properties in the study of insecticides and fungicides.

Under the same project Robinson is cooperating with Childs at Hood River in determining the effectiveness of certain spreaders used with bordeaux mixtures for the control of Anthracnose. The incentive lies in the fact that an efficient spreader and adhesive may make it possible to cut down in the number of bordeaux applications for the control of this disease in the Hood River section.

Robinson finds also by laboratory work that bordeaux mixture can be rendered highly effective or almost worthless by varying the procedure followed in getting it into the spray tanks. In cooperation with Childs exact methods of precedure for best results have been formulated and passed on to the growers of the Hood River section.

Chemical Investigation of Acid Soils

Under Adams Project No. 23, Robinson has continued the study of certain soil types that are acid in reaction but which do not respond noticeably to applications of limestone. The soil solution has been the immediate object of study this year, but no results can be reported at this time.

The Composition of Legumes

During the year, work undertaken some two years ago on the chemical properties of Pacific-Coast-grown legumes was completed. The station now has adequate information regarding the composition of our more commonly grown forage crops for use in the feeding of livestock or agronomically in dealing with questions relating to these crops and soils which produce them. It was intended that this work should be followed immediately by such nutrition experiments as will determine the relative merits of our more prominent legumes for feeding purposes and the extent to which they may be made to meet animal body requirements for the mineral elements. State funds have supported this project.

Yellow Berry in Wheat

With Stephens at the Moro Branch Station, we are trying to find the cause and remedy for yellow berry in Turkey Red Wheat. Thus far it is plain that available soil nitrogen helps in a measure to reduce the percentage of yellow berry kernels in the harvested crop. Plots that are cultivated in such a manner as to stimulate the activity of nitrifying bacteria respond with the lowest percentage of yellow berry. There are factors concerned, however, whose exact nature we have not yet definitely found out. In the laboratory we are endeavoring to find out by physical-chemical methods if the several tillage plots involved can be differentiated on the basis of concentration of electrolytes in the soil solution during the growing period. We have as yet no definite results to report. The incentive for work here of course lies in the fact that hard, flinty, amber-colored Turkey wheat always commands a premium of from 2 to 3 cents per bushel over the softer, spotted, light-colored grain of the same variety. The percentage of yellow berry in the Central Columbia River Basin counties some years very appreciably lowers the commercial value of the crop.

Maintainance of Organic Matter in Columbia River Basin Soils

During the past year, also in cooperation with Superintendent Stephens, we have undertaken to determine whether it is possible by any practicable scheme to maintain the content of organic matter in the soils of the Columbia River Basin under cultivation. Actively decomposing organic matter imparts "life" to soils, favors that condition called "good tilth" and increases their water-holding capacity. It would seem that some scheme must be devised for getting new organic matter into these soils if their present condition of reasonably high fertility is to be maintained. Hence our interest in this work.

Soil Analyses

In connection with the systematic soil survey work of the Soils Department the chemical work has about kept pace with the collection of samples from surveyed areas. A write-up was given the work of previous years and incorporated in a Station publication entitled, "A Preliminary Report on the Management of Willamette Valley Soils." This publication is the joint product of the Department of Soils and the Department of Agricultural Chemistry.

Analyses of Spray Materials

Approximately nine weeks' time of one man has been devoted to cooperative referee work in the interests of improvements in methods of analysis of spray materials looking toward improved products of these materials.

Fertilizer Inspection

In carrying out the provisions of the State Fertilizer and Agricultural Lime Laws, 151 samples of commercial fertilizers, limestone, hydrated lime, and land-plaster were collected and analyzed and inspections of dealer's stocks were made. No flagrant violations of the laws are apparent.

Miscellaneous

A total of 276 miscellaneous chemical analyses were made during the biennium for other departments, branch stations, and individuals, mainly for other departments in connection with their experimental projects.

DEPARTMENT OF BACTERIOLOGY

The major investigations of this department are closely correlated with investigations of Agricultural Chemistry and Soils in an effort to find a satisfactory answer for certain troublesome problems of Oregon agriculture. In addition the Department is called upon to render to other Departments and to the public a very great amount of service, which reduces organized investigation greatly.

Effect of Lime on Biological Activities in Acid Soils

Three prominent soil types representing large areas of land in the Willamette Valley have been studied under greenhouse conditions to determine the effect of lime on the biological activities and the crop-

producing power of these soils. The types of soil studies are known as "Willamette Silt Loam," "Whiteland," and "Amity" (which is an intermediate type).

In the greenhouse each sample was sieved through a ten-mesh sieve and divided in eight parts. Each part was then placed in a four-gallon jar. Two jars of each soil type were treated with no lime, two, four, and six tons of lime per acre, respectively. One set of jars representing each treatment was planted to clover. At intervals observations have been made on the number of bacteria and molds in the soil, the nitrate content, the ammonifying, nitrifying and nitrogen-fixing powers and the hydrogen-ion concentration. These results have been correlated over a period of time sufficient that certain conclusions seem to be warranted. It seems apparent that under greenhouse conditions the biological processes in these soils are stimulated when lime is applied. Especially is the nitrifying power increased in all the soils studied.

The yield of clover except in the Amity soil was increased by the application of lime up to four tons, beyond which point a depressing effect was noted. The failure of the Amity soil to show crop response is probably due to the fact that it was taken from a field that had previously been limed and had shown remarkable crop response.

Studies of the H-ion concentration of these soils show that wherever the crop-producing power of the soil is depressed by the application of lime that the P. H. value is 7.0 or numerically greater. This is in keeping with the results of Salter and McIlvaine (Jour. Agr. Resch. Vol. 19, pp 73-95, 1920). We believe that the growth of plants is more closely associated with the degree of ionization than the titrable acidity.

Studies On Sulfur Oxidation In Soil

The enormous quantities of sulfur used as fertilizer in certain sections of Oregon make it imperative that a careful study be undertaken as to the mode of action before recommendations be made for its general use. Realizing that sulfur must first be oxidized to the sulfate form before it can be used by plants, and that the sulfuric acid produced in this oxidation has a solvent effect on the phosphates of the soil, two explanations can be tendered to account for the phenomenal increase in the growth of alfalfa in certain sections of this state. Since 100- to 300-percent increases in yield have been obtained from the use of 100 pounds of sulfur per acre on soils where the application of phosphates had little effect it seems safe to conclude that this crop response was due to the actual supplying of a limiting plant food element.

Since the oxidation of sulfur is largely a biological process, it is necessary to find what conditions in the soil accelerate or retard this action. With a view to answering the many questions arising in connection with sulfur oxidation, a study has been made of samples of soil representing the irrigated Columbia Basin, irrigated soils of Southern and Central Oregon from both the Medford and Klamath areas, muck soil of Marion county, and two prominent Willamette Valley soil types.

The investigations so far completed seem to warrant the following conclusions:

1. All samples included in this investigation can oxidize sulfur as rapidly as would be required for maximum crop production, although there exists a wide variation in the comparative sulfur-oxidizing power of these different soils.

2. No apparent relation exists between the total sulfur content and the sulfur-oxidizing power of the soil.

3. The application of sulfur to a soil brings about an increase in the sulfur-oxidizing power by making the soil a more favorable medium for the growth of the sulfur-oxidizing organisms.

4. "Activated" or inoculated sulfur stimulates sulfur-oxidation, but for the soils studied there is no indication that such "activated" sulfur is more valuable for general field application than is ordinary commercial sulfur.

5. The temperature and moisture of the soil seem to be the important factors affecting the rate of sulfur oxidation, although sulfur oxidation is very strong even in the air-dry soil.

Miscellaneous Investigations

Several minor problems have been given what attention was possible with the limited time, money, and equipment at our disposal.

Hemorrhagic septicemia. Due to the total lack of facilities for housing experimental animals, and lack of funds, little laboratory work has been done on this disease during the fiscal year. Efforts have been confined to field observation, treatment with vaccine both as a preventive and curative measure; and improvements in the vaccines used. Almost without exception the vaccine made from attenuated, living organisms prepared by this department, controls the disease within a few days if diagnosis has been correctly made. The vaccines have been improved throughout the year by growth on different media and the former difficulty of keeping the culture growing in the laboratory has been overcome. The State Veterinarian, and many practicing veterinarians, dairymen, and stockmen throughout the state are using the vaccine regularly, both as a prophylactic and as a curative measure. In a large band of sheep in which ten or twelve animals are dying daily, it is the exception when the deaths do not cease and the disease disappear within a week after all the animals have been vaccinated. Cattlemen bringing cattle in numbers into the state or shipping them out of the state in sections affected by *Hemorrhagic septicemia* are making a practice of vaccinating all animals as a protective measure. The vaccines as sent out, are prepared from living attenuated organisms, to be used within a few days after the culture is prepared. The work has progressed to the point where the department can recommend the vaccination of all the young animals (sheep and cattle) each year as a preventive, and the immediate vaccination of all animals upon reasonably certain diagnosis of the disease. There is a great need of investigational work on this disease to determine such points as (a) natural habitat of the organism, (b) channel of infection, (c) means of exit from the body, (d) "reservoir of infection" between outbreaks, (e) more definite and positive diagnosis.

Infectious Mastitis of Cattle. A beginning has been made in study of this serious disease of cattle as to its extent in the dairy herd, the

manner in which the disease is spread, the economic loss, and the etiology of organism, to be followed later by attempt at control.

The preliminary work consists of a study of the "udder flora" of all animals showing a history of infectious mastitis, and those animals which develop the disease during the progress of the investigation. It is a common observation that animals, once infected, have a recurrence of the disease often in the same quarter. This frequently spreads to all quarters. This brings up the question of "reservoir of infection" during the interim in which the animal is apparently free from the disease; also the question of what is the greatest source of danger in the spread of the disease. To make the investigation as comprehensive as possible, the following data are to be gathered in regard to cows infected with the disease.

1. Complication with contagious abortion.
2. Method of milking.
3. Record of milk production.
4. Position in barn.

Bacterial examinations are being made at intervals of all these affected animals for possible "carriers" of the disease. While the work has not progressed far enough as yet to draw any definite conclusions, it seems apparent that most of the animals studied harbor an organism, identical with *"streptococcus mastitis,"* indefinitely after recovery from the disease. More detailed study of these organisms is necessary.

Legume Inoculation Cultures. The department furnishes a considerable number of inoculation cultures to farmers of the state each year.

From six thousand to ten thousand acres are supplied annually according to economic conditions, crops sown, etc. This is done to assist the farmer by making it unnecessary for him to buy cultures at fabulous prices, sometimes represented as valuable for other crops besides legumes, and to give the College definite information of the value of artificial inoculation.

The cultures prepared by the Department of Bacteriology are much larger than commercial cultures, fresher, and more vigorous in growth—and they are sold to the farmer at cost. The plain truth is told about their value, their limitations, and the probability of success. These latter facts have been worked out by field observation, field tests, and laboratory experiments. The charge made is twenty-five cents per acre, post paid, and the product is sold only where there is need of it, and where there is a fair chance of success. This makes a total cost to the state this year of fifteen hundred dollars for six thousand acres. In recent years one commercial concern, charging two dollars per acre, with postage additional, took orders for ten thousand dollars' worth of culture from one county, where the value of inoculation was still in doubt.

Miscellaneous Service

Under this heading is classified all the bacteriological work done for the departments, for the institution, for communities having definite bacteriological problems, for industries, and for individuals operating

on a large scale, especially when their problems are such that they are likely to occur in increasing numbers in the future. Bacteriological tests and analyses of all kinds for the fiscal year total 850. Some of the more definite bacteriological problems which have been attacked are as follows:

1. The bacterial examination of milk handled by the Dairy Department of the College, and control methods to keep the quality high. This includes routine tests (170 during the college year), and special tests and investigations when troubles of any kind have developed. This same service has been extended to the milk producers selling to the College Creamery.

2. Special bacterial tests to determine the value of a new commercial method of testing the market value of milk, the trade name of which is "Contamotester." This test consists of a commercial adaptation of the well-known laboratory "reductase test" of milk and has possibilities of being of considerable value to the creamery and market-milk interests of the state.

3. Special bacterial tests of a new method of preserving milk. This also offers commercial possibilities which would make for great economy in handling market milk and be a big asset to the dairy industry of the state if perfected.

4. Hundreds of tests of water for sanitary conditions, both for communities and individuals have been made. These are followed up by routine inquiry into the conditions surrounding the water supply, and recommendations are made for the improvement of water when it is found unsanitary. In one instance the water supply of a city of six thousand was cleaned up by the efforts of the department. Two other communities of several hundred inhabitants each are still working with the department in an attempt to purify the water supply.

5. Food Spoilage. The department has been able to render important service in the case of improperly processed fruits and vegetables. The cause of such trouble as "flat sours," "swells," and moldy products have been determined. The effect of chemical reactions upon sterilization, the rate of penetration of heat, the value of vacuum, and the etiology of organisms causing spoilage have been worked out in cooperation with the Department of Horticultural Products.

6. Miscellaneous bacterial analyses. A large number of such analyses have been made for individuals, companies, and communities; letters written and information dispersed. In many cases the work is original as far as the adaptation to Oregon conditions is concerned.

DEPARTMENT OF ZOOLOGY

The Department of Zoology again has been represented on the Experiment Station Staff in a limited way only. The small amount of time devoted to experimental work has been devoted to a continuation of the studies on the pocket-gopher and the Townsend mole.

Pocket-gopher, (Thomomys quadratus quadratus)

This gopher is destructive, especially in Eastern Oregon. It differs in habits and requires different treatment from the Western Oregon

gopher previously reported upon. The life-history data have been collected in the field, and valuable information has been obtained in cooperation with private individuals.

These data, with field experiments on methods of poisoning, give sufficient information to warrant a preliminary report in mimeographed form, including the methods found most satisfactory for control of the gopher. The recommendations are being followed successfully by farmers who have tried them.

Townsend Mole

On this project it has been possible only to gather a large amount of data bearing upon life-history study, natural habits of the mole, comparative test of traps, a study of the food of the mole, and preliminary work in poisoning investigations. Extensive observations on these phases were made in 1920 and 1921. They are being continued on a very limited scale, and the material is gradually being prepared for conclusions and publications.

DEPARTMENT OF FARM MANAGEMENT

Owing to limited station funds the work of the Department has been confined to studies continued at small expense to the station through cooperation with the Extension Service and with the United States Department of Agriculture.

Land Clearing

Foreseeing that the logged-off land question would some day become acute in this state, the Oregon Experiment Station since the year 1910 has given study to the land-clearing problem. Little search was required to show that while it was possible to clear grub oak and other small stump land at a cost somewhat lower than the actual value of the land when cleared, it was also found that clearing of big stump land was economically not feasible.

The first progress made by the Experiment Station was in its studies of the char-pitting method during the years 1910 to 1915. Satisfactory studies made of this method showed that it was lower in cost than any other method of land clearing then in use. The difficulty of learning how to use the method successfully, however, made this method impracticable, and though some effort was made to put the method into the hands of the farmer, it could not be done successfully and the method has practically passed from use.

In 1915, the Experiment Station in the course of its work came upon Mr. S. F. Zysset, a farmer of Scio, Oregon, who had constructed an appliance for burning stumps that looked promising. As no data on the cost or best methods of use were at that time available, the Experiment Station at once undertook a careful time, cost, and use study of this burner, under varying conditions, to determine for itself as well as for others the economy and practicability of the method. Since the year 1915, the major tests of this method were made, these being followed up with a number of minor tests and comparisons with ordinary methods on the same land. Time and cost records were kept, determining the total time and cost required for clearing land with this method, and time and cost for each part of the operation, and these

under varying conditions of soil, weather, and kind and character of stump. Further, tests were made of different ways in which the burner might be used under the same conditions in order to determine which was the most economical and surest of results.

As a result of these investigations, the Experiment Station has become convinced that the method is thoroughly practical, that it is simple and easy to learn, that it will reduce the cost of clearing the average big-stump land fully 50 percent, that it has all the virtues of the old char-pitting method while doing away with its difficulties and objections.

This method is no longer an experiment, but has been successfully demonstrated. Although done with slender and insufficient funds and hence but slowly, this investigation has given results that will affect materially the conversion of something like eight hundred thousand acres of agricultural land in Oregon, now in stumps non-productive and a burden on the taxpayers, into wealth production and tax relief. Many thousands of acres of big-stump land in other states will also be affected by the results of this study.

Cost-of-Production Investigations

Wheat Production. A wheat-cost and wheat-farm-organization survey study has been undertaken covering 150 wheat farms in Sherman county, typical of the Columbia Basin wheat-producing region. This is the most complete, careful, and detailed cost study that we have made. It was started in 1921 and is to be continued 1922 and 1923, and we believe will give complete and exact information on cost of wheat production as well as wheat-farm organization for Eastern Oregon. The study is in cooperation with the Extension Service and United States Bureau of Farm Management and Farm Economics. Preliminary reports of the 1921 data have been prepared in mimeograph form.

Milk Production. Cost of producing milk and butter-fat on 120 farms in the lower Willamette Valley was undertaken in 1920 in cooperation with the Extension Service and Dairy Department. The results have been tabulated and mimeographed. The study was continued on 75 farms in 1921, and results are now being tabulated. In 1922 records are being kept on approximately 100 farms.

Alfalfa Production. In cooperation with Extension Service a farm survey and cost-of-producing-alfalfa study were conducted on 140 farms in Malheur county in 1919 and 1920. The data are in mimeographed reports. The study was continued on 60 farms in 1921.

The wheat-cost study is to be continued this year, the survey being repeated for the same farms in the same region, and this is true also of the other two projects. It should be possible to issue a publication on the wheat-cost and wheat-farm-organization study covering two years' work and publish as a progress or preliminary report in 1923. It is desired to extend and make much more complete both the milk-cost and alfalfa-cost projects, so that satisfactory materials for publication may be available within the next two years.

Minor Projects

Shelter Shed Study. During the year additional reports have been secured covering the use of shelter sheds as an economic method of manure handling and preservation.

Applied Farm Management. Complete organization plans for four additional farms have been completed and work on them initiated during the year and records of their progress started.

Work on the plans for seven model farm buildings has been completed, after several years of study and actual construction and use tests, and the plans made ready for distribution.

DEPARTMENT OF HORTICULTURE

PRUNING INVESTIGATIONS

The principal energies of the Research Section have been applied to work on the Pruning Investigations project provided for by Federal Adams funds. The experimental results coming from this project are briefly as follows:

1. Relation of various pruning practices to internal food changes in the tree:

Results have been chiefly of a general nature, although considerable specific data have been obtained. This study has further emphasized the necessity of regulating the pruning practice to the varietal habits of the trees in question, and the hazardous nature of most summer pruning practices. The specific data include crop and growth records, starch transformation, total nitrogen and carbohydrates of the leaves, and root studies.

2. Relation of leaf area of the individual spur to its chemical composition and the set of fruit:

It was found that the set of fruit on a spur is practically proportional to the leaf area remaining after various degrees of defoliation; the food constituents of the spur show corresponding variations.

3. Relation of leaf area of individual spur to its chemical composite and the formation of fruit buds:

This was finished after the last biennium report had been made. It was found that fruit-bud formation is prevented if the spur has not an adequate leaf area. The effect of defoliation of the spur on the food constituents largely explains such hindrance of fruit-bud formation.

4. Relative influence of leaves and developing fruits on chemical composition of spurs:

The results of this study have not yet been assembled.

5. Effects of branch ringing and defoliation on the set and development of fruit:

Some of the results to date are very striking. By combinations of ringing and defoliation operations, the fruit-setting and fruit-developing processes of the spur-bearing portion of the branch can be closely controlled. By this means the relative value of the elaborated food supply coming from the leaves of the summer shoots, of the leaves of the spurs, and the basal portion of the limb can be estimated and studied.

6. The physiology of summer shoots. The effect of ringing and defoliation on the growth and chemical composition:

Some important facts have been found regarding the relation of growth to the source of supply and the chemical composition of the tip

of the summer shoots. The changes which take place in the pruning stub leading to new shoot development after summer heading have thus also become better understoood.

All the special studies recorded under numbers 2 to 6 inclusive are aimed toward an understanding of the fundamental processes governing growth and fruit production of the tree, and we believe that the results already obtained have thrown new light on this field.

PEAR HARVESTING AND STORAGE INVESTIGATIONS

This work has not only contributed important information relative to pear storage practices, but also has led to the establishment of a new criterion for determining stage of maturity. This is becoming recognized as being very valuable in determining the time of harvesting of the pear. The method used to determine maturity is known as the "pressure test" and has been developed to the point where a very neat machine for this purpose has been perfected. Replicas of this machine have been sent to several different branch stations and commercial pear-growing districts.

Pollination and Fertilization of the Filbert. It was found that while pollination of the filbert takes place in January or February, the act of fertilization does not occur until June. This is both a remarkable fact and one which must be taken seriously into account in all future pollination and breeding experiments with this fruit.

A Study of Changes of the Pear Fruit. This has shown a correlation between the gradual lowering of resistance of the outer layers of the pear fruit to pressure and histological changes in the cell walls and thus tends to explain the "pressure test" for the maturity of the pear.

FRUIT BREEDING AND VARIETAL TESTS

Strawberry

Varieties. For some years the number of strawberry varieties fruiting under Oregon conditions has been very small. Only six commercial varieties have been recognized until two years ago, when test was begun with twenty new varieties. After two years, it is clearly seen that the only additional introduction of commercial importance for the canning and shipping trade is the Ettersburg No. 121. No other new varieties tested are of importance for the fresh-fruit trade.

Pollination. Pollination on Ettersburg No. 121 demonstrated that it is a self-fertile variety.

Breeding. About 400 seedlings of different varieties crossed upon Ettersburg No. 121 have been grown for one year and fruited for the first time this season. Several promising seedlings have developed. Some hundred more seedlings were planted this spring and will fruit next year.

Apples

Apple Breeding. The object of this work has been to produce if possible varieties which will be better suited to the soils and climate

of Western Oregon than any we now possess. It has been realized for some time that we need a brilliant red apple for the Willamette Valley and Western Oregon in general. With this in mind, a block with several hundred apple seedlings was planted eight or ten years ago. The last of these trees had fruited by 1921. None of them proved desirable enough to retain. A young block of some three hundred seedlings, about five years old, is now just coming into bearing.

Variety trials. Several new varieties of apples have been introduced for trial. Among the most promising are the Red Rome and the Golden Delicious. The Red Rome has fruited and has been under observation for the past two years. It produces a brilliant red color under Willamette Valley conditions and is of the same quality and appearance as the old Rome Beauty variety. The Golden Delicious so highly advertised in some other sections will be fruiting on the experimental farm this year for the first time.

Cherries

Pollination. Records kept on a block of 360 sweet cherry seedlings planted eight or nine years ago have shown them to be all self-sterile. Cross-pollination tests have shown several of the best seedlings to be excellent pollinizers of our regular commercial cherries, and considerable promise lies in this direction.

Breeding. Several cherry seedlings have been found to possess excellent quality either for home use or for canning and shipping. Other seedlings are being watched carefully in an effort to procure varieties that are either extra early or very late in maturity, hoping in this way to prolong the harvesting and marketing season.

Filberts

Pollination. Pollination tests have shown that all varieties are self-sterile. Cross-pollination work has been carried on for the past two years. It is hoped that the results of this year will determine the best varieties for cross pollination of the Barcelona and DuChilly, two of the most important commercial varieties.

Breeding. Nuts resulting from cross pollination have been planted in our nursery and will be fruited.

Propagation. In view of the fact that the old method of propagation by suckers rising from the base of the filbert tree was a very expensive one, it seemed best to try other methods of propagation with the idea in mind of cheapening the cost of filbert-tree nursery stock. Experiments in propagation by cutting the grafts or by layering has been started. To date, following two years of work, propagation by cuttings has been found to be a failure. Early grafting is also uniformly a failure, while late grafting has proved only a fairly successful process. By far the most promising methods seem to lie along the lines of layerage in different forms.

Prune Breeding

A small block of prune seedlings is under test. Most of these seedlings are entirely unpromising. There is one, however, that gives a higher sugar content than any other prune which the Department of

Agricultural Chemistry has analyzed. It is a free stone and makes an excellent dried prune. It is of good size and appearance and bids fair to have an excellent future.

Pears

Pollination. Pollination of the Anjou variety was begun in the spring of 1922. No results are available as yet. It is hoped that this work may eventually throw some light upon the serious problems of the drop of the young Anjou pears.

Breeding. A block of pear seedlings on the experimental farm will be fruited the first time this fall.

Walnut Pollination

Due to the fact that the walnut trees set on the experimental farm had suffered ever since planting through frosty conditions and too much moisture at the roots, the work upon the walnut varieties had always been very uncertain. In fact, during the several years that pollination work was attempted upon these walnut trees, nothing but disappointment was experienced due to conditions beyond the control of the experimentor. Therefore it was decided to pull out these trees and discontinue the work. This was done during the year 1921.

VEGETABLE GARDENING INVESTIGATIONS

Greenhouse Vegetables

Crop rotations in the greenhouse. Trials have been conducted during 1921 and 1922 to determine if possible the best methods of greenhouse management, the main problem being a choice of the best crop rotations to grow in the greenhouse under existing marketing conditions. Results show that one of the best combinations for this market and climate is that of growing tomatoes March to August, followed by three crops of spinach, or as an alternative, tomatoes from March to August followed by a fall crop of tomatoes and one crop of spinach. Spinach, it is found, can be made as profitable a greenhouse crop as leaf lettuce used to be when it was grown prior to the shipments of winter head lettuce from California.

Tomato Pollination. This work has been conducted throughout the biennium. It has been found that 80 percent of the blossoms of the plants which were hand pollinated produced marketable fruit, while unpollinated plants averaged but 50 percent of a crop.

Tomato Mosaic. This disease was quite prevalent during the year 1921 in the Experiment Station greenhouse, and cooperative observations have been tried out with the Department of Plant Pathology. Methods of control have been perfected to such an extent that the disease has been much less in evidence during the year 1922.

Field Experiments

Broccoli seed strains. Thirteen seed strains of the St. Valentine variety, one of the most widely grown, showed considerable variation in value. Variations in earliness of marketing by March 1 was from 80 to 8 percent. The amount of No. 1 grade heads varied from 88

to 16 percent. Culls ran from 0 to 57 percent. The best strains have now been segregated for planting stock, and some of this seed is being tried cooperatively by growers. Reports are due from some of these growers next spring. The future of the broccoli industry depends very largely upon the united effort between the growers to produce crops from the best strains only.

Testing Mentha citrata under Oregon conditions. This was begun in the spring of 1922 in cooperation with Mr. W. W. Stockberger of the Bureau of Plant Industry of the United States Department of Agriculture. This particular mint comes highly recommended for its value in oil and should it prove successful under our conditions will be a considerable improvement over the common strains of mint now being grown. The test is being made on Lake Labish bottoms near Brooks, Oregon.

HORTICULTURAL PRODUCTS INVESTIGATIONS

Prune Drying

This project was begun in the fall of 1921 and has only been partly completed due to the shortness of drying season of that year. Results of investigations thus far carried on have shown that temperatures as high as 180° F. with high humidity are injurious to prunes. Temperatures of 150° F. with 20 percent humidity gave better quality.

Recirculation of Air in the Oregon Tunnel Drier

This experiment was started in the fall of 1921 with prunes. The drier was tried out with approximately a full load and the experiment proved so promising that it will be tried again thoroughly during the fall of 1922, to obtain more data upon the cost of operation. By connection of fans placed in such a manner as to induce artificial draft, the rate of drying prunes was increased to the point where actual drying time was reduced from one-half to two-thirds and the quality of the prunes was much improved, with a reduction of about two-thirds the number of "dobies" we find in drying under ordinary methods.

Drying Apples

This project has been under way during the entire biennium. The object of the investigation is to note the effect of different treatments upon the fruit tested, combined with the effects of different humidities and different temperatures upon the dried product. The data for this experiment have been compiled but not worked out. This will be done in the very near future.

The following minor projects have been worked upon to some extent as time permitted.

Canned Dried Prunes

A plan for commercial canning of dried prunes was worked out whereby it will be possible for manufacturers to apply this method direct to commercial practices.

Apple Confections

A method was tried out whereby it was found feasible to make over waste pomace coming from the manufacture of cider and to make a good confection easily and cheaply.

Broccoli Canning Investigations

Broccoli has been a vegetable difficult to can because a condition known as "flat sours" has shown up repeatedly. It has been thought by most cannery men that broccoli could be cooked under open bath conditions, but experiments carried on have shown that broccoli cooked in retorts at sufficiently high temperatures came out entirely free from contamination, while the vegetable cooked under open bath conditions showed a high percentage of flat sours.

Blackening of tin in canned cauliflower was noted and tests were made to determine cause. It was found that the sulfur compounds present in the broccoli caused formation of tin and iron sulfates by action of hydrogen sulfide given off from the broccoli during processing.

It is recommended that a retort cook be given broccoli for eight minutes at 236° F. minimum for No. 2½ cans, with a fill of from 17 to 18 ounces. This has been found to apply to the canning of cauliflower as well.

MISCELLANEOUS INVESTIGATIONS

Frost Injury Observations

The unprecedented freeze of 1919 left many fruit trees severely injured and in a weakened condition. Since that time observations have been made regarding the results of the winter injury upon vegetative growth, fruiting, heart rot, etc.

Experiments upon a commercial scale have been tried in grafting stumps of eleven-year-old trees injured by the winter of 1919. These stumps were cut low enough to avoid heart rots, and bark grafts were set for the most part. To date the grafts in the majority of cases are doing fairly well and bid fair to make strong trees in time.

Depth of Planting

This experiment was completed in the fall of 1920 and reported upon in the Third Crop Pest and Horticultural Report. It was found, briefly, that the depth of planting on several different kinds of trees tested and under the conditions surrounding the trees showed no material effect upon trees up to six years of age. Those planted the maximum depth of 27 inches seemed to do as well as those planted either shallow or medium depth.

FERTILIZERS

No fertilizer experiments were made upon fruit trees during the last bienmum. Applications of nitrate of soda and sulfate of ammonia were made upon small fruits in the neighborhood of Brownsville two years ago. This was the second year of the fertilizer experiment upon this particular berry farm. The canes had seemingly been stimulated into somewhat later growth the previous year than was found on raspberries not fertilized, consequently the growth of the patch was not uniform due to winter injury, and the results could not be checked as closely. Results of the application of nitrate in 1919 have shown that about 10 percent was gained in the tonnage of berries per acre where fertilizers were used.

In the spring of 1921 a commercial patch of loganberries, red raspberries, and Evergreen blackberries was treated with nitrate of soda and sulfate of ammonia at the rate of 250 pounds to the acre. This berry patch was located along the road to Albany north of Corvallis about two miles. No results were evident on loganberries and red raspberries, but weighing of the blackberry crop showed evidence of increase of about one-sixth in the crop where the nitrate was applied. Results might have been different upon loganberries and red raspberries if proper cultivation had been carried on by the owner. This points to one of the disadvantages of cooperative experiments; namely, the inability to control conditions.

OTHER SERVICE

Believing it to be in the best interests of the work for people to understand that Experiment Station workers are called upon to spend a considerable proportion of their time in other forms of service, a careful approximation has been made of the secondary work of men engaged in experimental activities in the Department of Horticulture. Addresses for the College, Extension Service, or for the Experiment Station, most of them entailing trips into the field, 110; personal service, committee meetings, 215; conferences, approximately 11,000 to 12,000; tours or trips about the campus with individuals or groups of individuals, 60. These are in addition to answering a large correspondence seeking information from station work.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

Experimental Results and Development of Practices

Apple Tree Anthracnose Control by a single summer spraying was demonstrated by the Station in 1920. Late fall spraying with its partial effectiveness is being rapidly supplanted by the use of bordeaux in one of the late codling-moth sprays, thus making possible a saving of one spray application annually for 20,000 acres of bearing orchard and this with no loss in effectiveness but instead with a gain in control results.

Onion Smut Control. Tests in cooperation with the Washington County Farm Bureau in 1921 demonstrated that in the growing of large onions excellent protection against onion smut on the most heavily contaminated beaver-dam soil could be secured by the use of formaldehyde (1 oz. to 1 gal. water) provided a stream of the solution not less than five-sixteenths of an inch in diameter is run into the furrow as the seed is dropped. As a typical example of the results may be mentioned a plot where the yield in the treated plot ran 364 sacks per acre while the untreated plot went 88½ sacks only.

Take-all Disease of Cereals. In 1921 occurred a serious outbreak of a foot-rot disease of winter wheat in the Willamette Valley which made a considerable number of fields not worth threshing. Through the assistance of the United States Department of Agriculture the Station was able to undertake an investigation of the disease which proved to be the well-known "Take-all" disease of Europe and Aus-

tralia. The investigation is now under way. The first results show that climatic conditions have a tremendous influence on the severity of the disease. It now appears probable that only in certain especially favorable seasons will the disease result in serious crop damage anywhere in Oregon.

Seed Treatment of Cereals, Old and New Methods. Cooperative experimental work between the United States Department of Agriculture and the Central and Branch Stations of Oregon demonstrated the serious dangers of seed injury from the ordinary formaldehyde and bluestone dip, showed the conditions under which the formaldehyde method could be used with least injury, and proved the great value of a subsequent milk-of-lime bath to counteract much of the injury of the bluestone treatment. Even under the best conditions, however, the danger of injury was by no means entirely eliminated. Hence tests have been conducted during the seeding for the 1922 harvest to determine the value of the treatment of wheat by dusting the seed thoroughly with powdered copper carbonate. To date results show that there is practically no injury to wheat from this method. The results on smut control are not yet complete but appear promising. Other new materials are also being tested. There is reason to hope that some satisfactory and simple method of treatment will be found which will eliminate treatment injury. The value of such an accomplishment may be judged when it is considered that treatment injury now destroys in one Oregon county alone (Umatilla) about 50,000 bushels of seed annually, according to reliable estimate.

Smut-resistant wheat varieties have been found as a result of the testing of over 900 varieties in cooperative investigations between the Moro Branch Station, the Central Station at Corvallis, and the Federal Office of Cereal Investigations. This forms a basis for breeding and selection work designed to give Oregon types of wheat suitable for the best commercial production in the various wheat sections which by inherent resistance may be expected eventually to eliminate about $400,000 lost annually from smut attack.

Potato Wilt Investigations. The studies of this seed-and-soil-borne disease have proved the necessity of rotation of crops and the value of field roguing in the control of the disease. It has been found that it will spread from plant to plant under ground during the growing season, that the removal of plants as soon as they show signs of wilt will tend to check somewhat this spread, but that spread to other plants is controlled far better by removing not only the plant showing wilt but also the plant next in the row on each side.

European Canker. This disease has been found widespread and destructive on several varieties of pears and apples in Oregon. Diagnosis of the disease has been rendered easier by the discovery of the early spore stage in young cankers. Preliminary tests indicate that the use of bordeaux mixture previous to the fall rainy season will be distinctly beneficial in the control of this disease. It is to be hoped that the control of European canker and apple tree anthracnose canker can be accomplished by one and the same application.

Loganberry Cane Dieback. The 1921 investigation of the seriously destructive cane dieback which appeared in more than ordinary severity in that year demonstrated that the death of the buds along the canes occurred during the winter where the canes were allowed to lie on the damp soil more or less covered with weedy vegetation while canes that had been trained up off the ground in the fall suffered none of this trouble. Fall training, while a great advantage in this connection, renders the canes more subject to damage from unusually cold winter temperatures that make their appearance occasionally, a fact brought out during the past winter.

Leaf-and-stem-infesting nematode of strawberry and other plants. This parasitic eelworm was found causing considerable damage to cultivated strawberries along the coast in Coos, Douglas, and Lane counties. It has also been found to a limited extent on other hosts. At several points on the coast it has been discovered on the wild strawberry close to the ocean. Advisory assistance has been rendered in connection with the efforts of the State Board of Horticulture to control the situation and the cooperation of the United States Department of Agriculture has been secured in carrying forward more intensive investigation of this parasite.

Mushroom Root Rot. In cooperation with the Hood River Branch Station work is now under way looking to the discovery of root stocks suitable for our orchards which are resistant to the attack of this widespread and destructive disease. An experimental planting has been set out at Hood River.

Wound disinfection and wood decays of orchard trees. On account of the widespread devitalization of orchard trees due to decay a study is being made of twelve different kinds of air-porous wound coverings to determine their effectiveness for wood-rot prevention. The use of copper tacks, which appeared so effective in previous tests against one common wood-rotting fungus, *Lenzites saepiaria*, has not proved effective against nine other kinds of wood-destroying fungi, some of which are among our most destructive forms. Methods of treating trees by surgery following winter injury are also being tested.

SERVICE

A regular free service for the identification of plant diseases and recommendations for control is maintained for the people of the state. Numerous office calls and an abundant correspondence are given attention in this connection.

An orchard-spray program, prepared annually in conjunction with the Station Entomologist, is published in the horticultural and farm journals of the state, besides being distributed from the station.

Numerous lectures are delivered on plant-disease subjects at various points through the state by members of the Central Station staff under the auspices of the Extension Service, and assistance is rendered to County Agents and Extension Specialists.

The White Pine Blister Rust was discovered in the Northwest in the fall of 1921. The services of the station have been freely

rendered in organizing the campaign required to meet the situation and guard our valuable stands of western white pines and sugar pines against the invasion. The station has become headquarters for the scouting work being conducted in this connection in Oregon.

The station has acted in a technical advisory capacity to the State Board of Horticulture in connection with plant quarantine problems such as those presented by the eastern filbert, pine blister rust, and strawberry nematode conditions.

DEPARTMENT OF ENTOMOLOGY

Investigational work in the Department of Entomology has progressed along much the same general lines as was reported for the last biennium. The bulk of the investigational work on two of our projects, it is hoped, will have been completed this fall. During the past biennium local outbreaks of unusual severity have occurred with a number of our commoner economic insects. This has afforded additional evidence, if such were required, of the need for a decided expansion in our lines of investigation when funds and assistance will permit.

A Study of the Physical Improvement of the Spray Solution and Its Effect on the Toxicity of the Insecticide.

Calcium Caseinate for use as a spreader in the spray solution is now manufactured commercially by a number of firms in the West. Tests with these commercially prepared materials and similar material prepared in the laboratory indicate: (1) the addition of the Caseinate spreader in combination sprays of lead arsenate-lime-sulfur materially delays the reaction between the two materials with the attendant formation of the undesirable sludge; (2) Caseinate spreaders in the late cover sprays on apple, by effecting a smooth, even covering of the spray over the fruit surface, minimize the uneven coloring of the highly-colored varieties of fruit, so undesirable and almost sure to occur where a blotchy spray covering is given; (3) in general, by effecting a more rapid covering and wetting of the sprayed surface, the addition of caseinate spreaders tends to increase the number of trees covered per tank of spray; (4) in toxicity tests carried out with caterpillars, no evidence was found to substantiate the theory that the addition of caseinate spreader adversely affects the toxicity of the arsenate spray.

Oil Emulsions. Acknowledging the possible superiority of an oil emulsion, attempts were made to develop an ideal emulsion for use as a spreader; i. e., one which is stable with all reasonable spray combinations and waters, universal in application, chemically inert, and of known constituents making its commercial duplication possible. A number of emulsions have been prepared, using various animal and vegetable oils. The Soponin solution has given the best results as an emulsifier. No definite results are as yet available.

Investigation of the Artificial Propagation and Distribution of Beneficial Predacious and Parasitic Insects

Investigations have continued along much the same line as previously reported. Some phases of the investigations were seriously hampered through insufficient funds for scouting work, lack of certain laboratory equipment, and lack of suitable greenhouse facilities.

Insect Enemics of Apple-Aphids. There is a definite seasonal succession of enemies preying upon the species of aphids under investigation. This succession fluctuates from year to year, but is fundamentally constant. The succession is influenced by inherent differences in the life cycles of the different species and is dependent to an extent upon environmental factors.

There appears to be a definite correlation between the numbers of aphids and the activities of the beneficial insects. Ladybugs apparently adapt themselves for survival of the late summer dearth of aphids by the practice of canabalism among the larvae.

Two manuscripts have been prepared for publication on certain phases of this project. One has already been accepted for publication by the Journal of Agricultural Research.

Peach and Prune Root Borer

Napthaline has appeared as the most promising material so far tested as the active agent for application in washes to trees to prevent the entrance of the borers. Slight injury resulted from the application of white washes containing napthaline when the coating extended below the soil surface. Roofing paper-napthaline protectors appear promising, especially for use on young trees.

Paradichlorobenzine, used so successfully in the East for the "Eastern root-borer," is being tested under Oregon conditions, both summer and fall applications being made. It is assumed that the information made available this fall, following the final checking on our experimental work will afford fairly conclusive evidence as to control, and permit the closing of this experiment as a major project.

Apple-Aphid Control Investigations

Ecological and biological studies have been continued. Cooperative experiments in control are under way in four commercial orchards. Various combination sprays have been tested comparatively as also have different dates of application. Late summer and early fall applications in these preliminary tests give excellent promise of control. In general, our tests would indicate that most growers apply the "delayed dormant" spray too early for maximum effectiveness in aphid control.

Leaf-Rollers and Fruit Worms

The leaf-roller continues as a major pest in portions of Hood River Valley. In older centers, however, where earlier infestation was most severe and where annual applications of oil spray have been made, the district is practically free from the pest. Likewise in the

Imbler fruit section of Union county, the severe infestation of a few years ago has been greatly reduced.

Further trials of possible ovicidal sprays were continued. In orchard spray tests, combinations of oil emulsions, 5 percent oil, with lime and glue, gave best results. In an elaborate series of tests where the materials were applied with a brush directly to the egg masses on the bark, eight different oils were tested and twenty-eight different combinations of organic materials with laboratory-prepared emulsions of cylinder oil were used. The most promising substance in these preliminary tests was picric acid in a cylinder-oil emulsion. No tests have been made to determine the effect of this substance on the tree.

Life-history and breeding-cage records on fruit worms have been continued. The prevalent species this season, a semi-looper, has in former seasons been a minor offender. In general, the application of lead arsenate in the "pink" spray on pear has proved, as in earlier tests, the best control measure.

The European Earwig

This insect was first reported in Oregon in 1916. It has become an obnoxious invader of residences and a pest of ornamentals and gardens in an area of several hundred blocks in the city of Portland, and also is well established in Albany.

The nature of the pest and its pernicious crawling habits, have aroused the citizens in the infested section of Portland to an unusual degree. An emergency project was launched last season in early midsummer and continued this year, seeking light on control. The use of a poison-bran bait, using sodium fluoride as the toxic agent, has been found and recommended as highly effective in control. This emergency project is practically closed, and the full report covering the investigation is in course of preparation.

Tree Crickets of Oregon

Additional information has been accumulated regarding the distribution of our Pacific Coast tree crickets, their host relations, and their relations to allied species inhabiting eastern states. Collections and observations were made in Southern Oregon, California, Arizona, New Mexico, Ohio, Minnesota, North Dakota, and Montana. A further study of the material taken is expected to throw some light on the status of our *Oecanthus argentinus*, which seems intermediate between eastern *O. nigrocornis* and *O. quadrimaculatus*.

Minor Projects

Codling-moth. Life-history and emergency records for use in compiling spraying date information have been continued. Preliminary tests of the use of baited traps are being conducted with fair promise of something of value developing.

Pear Leaf Blister-mite has been serious on pear in Oregon since 1896. It was first reported on apple in Union county in 1919, though the general nature of the infestation would indicate its attack on

apple had started some time before. It was first reported on apple in Western Oregon from Lane county in 1920, and was reported on apple in the Hood River Valley in 1921. Specimens of foliage of the mountain ash, showing typical blister-mite injury and believed to be due to this species, were received from two districts in Multnomah county in 1921.

Because the standard application of lime-sulfur in the dormant has apparently not given satisfactory control in all cases under orchard conditions, tests of sprays in control were made. Applications of materials were made on two dates, February 17 and March 2. Eleven sprays or combinations and dilutions were tested. (1) Dilutions of commercial lime-sulfur greater than 1 to 12 did not prove 100 percent effective. (2) Oil sprays are not effective in blister-mite control. (3) A combination of lime-sulfur, 1 to 12, plus oil emulsion, 2 to 100, is a highly efficient blister-mite spray and is to be recommended where the infestation is especially pernicious. (4) Dry lime-sulfur, 1 to 4, gave excellent results. (5) Where spraying for blister-mite on apple, the earlier application is advisable.

The Pear Thrips appeared in excessive numbers in Marion county this year for the first time since 1919. Unfavorable climatic conditions in the meantime have apparently prevented wholesale emergence or injury. New outbreaks were reported and inspected this year in northern Douglas county; also larvae (conditionally determined as pear thrips) were received from Umatilla county, and reported as doing some injury.

Arrangements were made for cooperative spraying tests, and a complete spray program on prunes was carried through in the Salem district. Results were largely inconclusive, as the climatic factor and other undetermined factors prevented the thrips from doing serious injury.

Tent Caterpillars have developed in unusual abundance during the past two seasons in Oregon. Numerous collections of the caterpillars were made and introduced into breeding cages to study for parasites. In general, the percentage of parasitism is from 30 to 90 percent, the major parasite being a Tachinid fly, undetermined.

Grasshoppers. Work on grasshopper control has been continued In tests of comparative attractiveness, using seven different mixtures as bait, bran and old sawdust in equal parts with molasses, salt, and amyl acetate proved the most attractive bait. Moisture is an important factor in rendering the bait attractive, and bran retains moisture better than sawdust. The addition of equal parts of the sawdust, however, improves the physical properties of the bait for scattering. Where sodium arsenate was substituted for white arsenic, the bait appeared less attractive, but killed in approximately one-half the time.

Wheat Straw worm, Meromyza sp. The work on the wheat straw worm to date has been largely field observations in Union county, where severe injury to spring grain occurred in 1920. The work is

in cooperation with the Federal Entomological Station. Volunteer grain is apparently an important factor in breeding and control work.

Onion Maggot Control. Limited cooperative tests in Washington county on onion maggot control were launched this spring to test the effectiveness of the British Columbia method of using cull onions as a lure. These preliminary trials are most promising. Slight modifications in the methods and improved technique in the practice of planting the cull onions will be inaugurated another season. The effectiveness of the attractive type of cull onion was established. Three hundred fifty-seven maggots were removed from one cull onion. Numerous examples were found where an excess of two hundred maggots were found in a trap onion.

The Gray Garden Slug is becoming a serious field crop pest in limited areas and under certain conditions. Reports of severe injury to fields of clover, rye, and oats were received from Clackamas and Washington counties. Preliminary tests of copper-carrying dusts gave promise of practical methods of control. Copper sulfate (dehydrated) 200-mesh dust and "Fungi-Bordeaux" dust killed every slug hit. Eight pounds of the dust to the acre appeared sufficient. Copper carbonate dusts were not equally effective.

The Pea Aphis appeared in serious abundance in Western Oregon in April, 1920. Tests with the mechanical "dozer" for capturing the aphis were made. Results were inconclusive.

Miscellaneous Breeding Cage Experiments. Rearing material sent in includes root-maggots, root-weevils and grubs, foliage and fruit-devouring caterpillars, Bibio larvae, borers, fruit worms, grain-infesting larvae, and other miscellaneous material.

SERVICE

Correspondence. For the year March 1, 1921, to March 1, 1922, approximately 2340 letters were written dealing with information of interest and value to the people of Oregon. In addition some 400 circular letters were sent out in response to inquiries, and 4 new circular letters covering topics of an advisory nature were prepared.

Emergency Work. The emergency calls in Entomology have been many and varied. Response to these calls for assistance where serious depredations threaten is imperative. A total of 160 days were spent in answering such emergency calls, including 22 days on grasshopper control, 36 days on alfalfa weevil survey, 12 days on strawberry root weevil survey, 2 days on pear thrips, 46 days on earwig studies, and 30 days on miscellaneous calls. In addition about 22 days were spent assisting at extension schools.

BRANCH EXPERIMENT STATIONS

The branch experiment stations at Astoria, Burns, Hermiston, Hood River, Moro, Talent, and Union continued investigations along the lines of the previous biennium. The work of each station has

been centered as in previous years primarily on the major agricultural problems of the respective agricultural section represented by the branch station. In addition the branch stations have cooperated with the Home Station at Corvallis in a few investigations for solution of problems common to larger sections of the state or the state as a whole. The character of work and the results are stated briefly in the following pages.

JOHN JACOB ASTOR BRANCH STATION, ASTORIA

The Astoria Branch Station continued to devote primary attention to the dairy production project and to farm crops, soils, and drainage problems of first importance in maintenance of successful dairy farms of the Coast Region of Oregon.

Dairy Investigations

All milkings were weighed and recorded, and records were kept of all feeds. A special study was begun to determine the effect of grain upon milk and butter-fat production while the cows are on pasture. The objects were to determine the actual increase in production from feeding grain and the returns in comparison to the added cost. Five cows were fed grain and five of the same herd were run on pasture alone, and accurate weighings were made of annual gains and losses, milk production, and butter-fat.

One year's data indicate that perhaps the main value of the grain ration is realized in production the following fall and winter and that profit from feeding the grain ration with pasture will depend upon relative prices of grain and dairy products. If they are about comparable cows yielding over 45 pounds of butter-fat per month on pasture may profitably be fed a grain ration.

The feeding of soiling crops as previously developed by the station was extended in practice. Computation of cow-testing-association records for 1920 showed an average increase of 27 pounds of butter-fat per year in favor of the cows that received soiling crops during the summer pasture period. Three years' results with the station herd showed a 15 to 20 percent production increase from feeding soiling crops during the summer months. The cash return depends upon price of dairy products, average milk production, and cost of producing the crops under the individual farm conditions.

Crop Varieties

Tests of crop varieties were continued. The Pomeranian white globe turnip yields 2 tons more per acre, has a better keeping quality and a longer feeding period than the cowhorn turnip formerly commonly grown.

Peas and oats introduced as a silage and soiling crop continue to give the best results in station trials, yielding an average of about 11 tons an acre green feed. This is a valuable introduction as it means more and cheaper feed, introduces a palatable leguminous forage, and reduces the bill for concentrates.

In the production of peas and oats the station tests have shown that early planting, about March 1, is important for successful produc-

tion. The yield is reduced about ½ ton an acre for each week delay in planting after March 1.

In tests with rutabagas the Improved American Purple top has proved the best producer by four tons an acre, an important item in Clatsop county.

Japanese barnyard millet, introduced by the station, continues the most satisfactory late soiling crop.

The potato variety trials indicate that most round varieties have a tendency to be of poor quality and subject to internal browning in this section. Pride of Multnomah and Early Rose have given best results.

Manure and Fertilizers

The most striking results continue to be from superphosphate and from superphosphate and manure. On the hill land 1000 pounds of superphosphate has given an increase of 7.3 tons an acre for turnips, and 13.5 tons an acre for rutabagas. Lime has increased hay yields and has helped to maintain the stand of clover. Results with lime and manure have been about 1.8 to 1.9 tons green feed better than with lime alone.

Drainage

The experiment in the draining of tide land by tile drainage has developed satisfactorily. Following a break in the dike in early 1921 a heavy covering of water was carried away through the drains in about ten days and the land cropped successfully. No crop could have been planted and grown had there been no tile drains.

Miscellaneous Service

The branch station is called upon constantly for advice and information in the management of dairy herds, as well as on farming problems, and is rendering valuable assistance. Early in the winter of 1921-22, for example, a balanced ration for dairy cows was worked out based upon station results, feeds available, and prices. The new ration was a saving to dairymen of about $8.00 per ton over rations in use. One dealer sold 400 tons of the new ration during the winter.

Unfortunately the funds available provide only for a one-man station and the time for both experimental work and service is limited accordingly.

HARNEY VALLEY BRANCH STATION, BURNS

The Harney Valley Branch Station was established in 1911 six miles east of Burns at an elevation of about 4100 feet on typical sagebrush land varying from sandy loam to sandy silt loam or clay loam spotted with alkali. The soil is considered average to poor for the Valley. The average annual precipitation from 1914 to 1921 was 9.02 inches.

The station was established to study problems of dry-farming, and its efforts were confined to this field until 1917. A deep well and pumping plant were installed in 1917 to provide water for irrigation and a study of irrigation problems. Since then problems of irrigation-farming as well as dry-farming have been under study.

Varietal Trials

Varietal trials with wheat, barley, oats, rye, alfalfa, field peas, and other crops have been continued, both under irrigation and dry-farming.

Dry-land Varieties

Results since 1911 on dry land indicate that the best varieties to grow are Early Baart and Hard Federation spring wheat, Turkey Red winter wheat, Hannchen barley, Sixty-Day oats, Vern spring rye, S. P. I. 26101, Grimm alfalfa, Kaiser field peas, Mammoth Russian sunflowers, early six weeks or early Ohio potatoes.

Varieties for Irrigation

The crops which have given best results under irrigation are Federation spring wheat, Turkey Red winter wheat, Trebi and Hannchen barley, Silvermine or Swedish Select oats, Grimm alfalfa, Kaiser field peas. The clovers are not well suited to Harney Valley conditions. Mammoth Russian sunflowers produce the largest tonnage for silage. Peas and oats are the best combination crop for the Harney Valley. Early maturing varieties of potatoes will do well in the warmer sections.

Rate and Date of Seeding

Dates of seeding vary about three weeks depending upon location and season. Results of experiments to date indicate the following as the most satisfactory on the average.

Crop	Rate of seeding	Date of seeding
Spring wheat	2 bushels	April 1 to 25
Winter wheat	2 bushels	Sept. 1 to 25
Spring barley	2½ to 3 bushels	April 20 to May 10
Spring oats	2½ to 3½ bushels	April 1 to 25
Spring rye	2 to 2½ bushels	April 1 to 25
Alfalfa	10 to 20 pounds	April 25 to June 1
Clover	10 to 15 pounds	April 25 to June 1
Field peas	1 to 2 bushels	April 1 to 25
Sunflowers	20 to 25 pounds	May 1 to 25
Combinations	2 to 3 bushels	April 1 to 25
Potatoes	1½ to 2 ounce piece per hill	May 15 to 25
Sugar beets	8 to 12 pounds	May 15 to 25
Mangels	8 to 12 pounds	May 15 to 25
Rutabagas	3 to 5 pounds	April 15 to 25

Tillage Experiments

The tillage experiments were revised during the biennium in further effort to improve moisture and assist in development of dry-land farming on several million acres of lands in Central Oregon. The main development to date is that the summer fallow should be plowed early in the spring and then kept free from weeds.

Rotation Experiments

A number of rotations are being tried out under irrigation. The best results to date are from a two-year rotation, grain following field peas; and a six-year rotation of alfalfa 4 years and grain 2 years. In the short rotation Federation spring wheat gave 61.1 bushels per acre compared with 23.3 bushels on adjoining plots

cropped continuously to grain since 1917. Grain following alfalfa in the six-year rotation yielded 26.6 bushels more than on continuously cropped land.

Fertilizer Experiments

Experiments with fertilizers were started in 1919. Differences in yield are apparent, but the results do not yet warrant any statement of comparative yields.

Duty-of-Water Experiments

Duty-of-Water experiments have been under way to determine the amount of water necessary to produce best results both on yield and in net returns for different crops. Results to date indicate best results from 12 acre inches per season for cereals, 18 acre inches for alfalfa, 12 to 15 acre inches for field peas, 15 acre inches for clover, 20 acre inches for Mammoth Russian sunflowers, 18 acre inches for peas and oats, 10 acre inches for potatoes, and 12 acre inches for beets and mangels.

Miscellaneous Service

The Harney County Branch Station is visited yearly by hundreds of prospective settlers in search of reliable information regarding the farming lands, yields, climatic conditions, etc. Information regarding varieties, tillage practice, irrigation agriculture, controlling pests, and on all phases of agriculture is given both by personal visits, and by mail and telephone. Field days are well attended and many practices that would otherwise result in failure are corrected.

Outstanding Accomplishments

1. Introduction and distribution of Early Baart wheat to Central Oregon farmers.
2. Introduction and distribution of True Spring Rye to Central Oregon farmers.
3. Introduction and distribution of Federation wheat as the best yielding spring wheat under irrigation.
4. Demonstrating hardiness of Grimm alfalfa.
5. Data on duty of water that will double the area of land that can be irrigated by gravity water in Central Oregon.
6. Demonstrating that profitable crops can be produced by irrigation from wells, by pumping.

UMATILLA BRANCH STATION, HERMISTON

The Umatilla Branch Station, located on the Umatilla project of the United States Reclamation Service, is conducted with the cooperation of the Office of Western Irrigation Agriculture of the United States Department of Agriculture. The soil is fairly representative of the sandy soils of the Columbia Basin, and the work during the past 13 years has been largely the investigation of the best methods of establishing permanent and profitable agriculture under irrigation on this soil type. The soil, climatic, and topographical conditions under which the station is working are typical of those

of eight irrigation projects comprising approximately 275,000 acres and of several hundred thousand acres of raw land in the Northwest which will be brought under irrigation in the future.

The principal lines of work receiving attention at the present time include soil fertility and rotation experiments, irrigation method experiments, percolation tests, crop testing, and hog feeding.

Fertility and Rotation Experiments

The sandy soils of the Columbia Basin are inherently low in organic matter and nitrogen so that the fertility problems are of first importance. The station is attacking these problems from a number of different angles, including manure applied to the common crops of the region, a series of rotation experiments, and the application of commercial fertilizers to field crops and to large plots in which the experimental conditions may be more closely controlled than in the field.

Manure applied to alfalfa at the rate of 8 tons per acre annually has produced over a seven-year period an average increased yield of 1.41 tons of hay per acre; applied at the rate of 32 tons it has produced an increase of 2.50 tons. The manure applied at the rate of 8 tons gave an increased yield of 352 pounds of hay per ton of manure, and at the rate of 32 tons the increase was only 157 pounds, showing very definitely that the greatest value was realized from the lighter application. Had the 32 tons been spread over 4 acres instead of 1 acre the return would have been 5.64 tons instead of 2.50 tons. One of the Experiment Station fields had been graded rather heavily in preparation for irrigation and had been in cultivated crops for a number of years, which resulted in more or less blowing and washing before it was put into alfalfa. For two years the growth was rather indifferent, the yield averaging only 2.56 tons per acre. An application of manure at the rate of 8 tons per acre gave the plants a start, and for three years following the yield has averaged 4.16 tons. Such conditions as these present possibilities for the most profitable use of manure and since the supply is limited it is especially important that it be carefully used.

Corn without manure produced .87 ton cured fodder per acre, with 8 tons of manure per acre 2.23 tons; and with 32 tons, 3.32 tons. In the rotation experiments on a slightly heavier soil corn following alfalfa turned under produced 5.61 tons of cured fodder per acre; following peas and barley hogged off, 4.24 tons; and following corn, 3.93 tons.

Percolation Tests

The tests of the rate and amount of percolation through the soils combine fertility and irrigation problems. In these tests large tanks which contain different soils growing various crops are irrigated with known amounts of water and the water which drains from the soil is collected and analyzed. Percolation from sandy soils did not cease for six years, but beginning with the seventh year the soils had been sufficiently improved so that they held all the water until the crops could use it. Applications of manure gave increased

yields, but the soil did not hold more water than where it was not applied. Analysis of the percolation water shows that less plant food is lost by leaching from a green manure crop turned under in the fall than from one turned under in the spring. The nitrate losses were highest from the manured alfalfa, slightly lower from the alfalfa not manured, and lowest from the fallow tank.

Irrigation Experiments

The irrigation of these sandy soils has presented problems which often baffled the settlers even though, as was rarely the case, they had had previous irrigation experience. Irrigation methods have undergone complete revolution since the project was established. When the furrow and wild flooding methods were proving inadequate for alfalfa irrigation, the station investigated the strip-border method and found that it saved much labor in preparation of the land for irrigation, that it saved water, and that the uniform distribution of water through the soil resulted in better crops of hay.

In 1911 the whole project used an average of 9.7 acre feet per acre of water, but the amount was gradually reduced through the use of the border method and better irrigation practice until in 1921 the average use was 4.5 acre feet. If the project had continued to use water at the rate of 9.7 acre feet per acre only approximately 60 percent of the present acreage could be supplied with water.

The size of strips laid off into borders bears a direct relation to the amount of water required to irrigate it. In one test, borders 20, 25, 30, 35, and 40 feet wide and all 200 feet long were irrigated to determine which width is the most economical of water. The average of five years results shows that the 20-and 25-foot borders could be irrigated with less than 4 acre feet for the season, but that the wider borders required approximately .50 acre foot of water additional for each 5-foot increase in width. Since any amount of water used over 4.00 acre feet per acre costs 75 cents an acre foot, it is a saving to use only the 4.00 feet. A length-of-border experiment, where a smaller head of water was used than in the width-of-border experiment, was conducted on borders 100, 175, and 250 feet long and 22 feet wide. The 100 foot borders could be irrigated with the base amount of 4.00 feet but the 175 foot ones required an additional acre foot, and the 250-foot strips 2.5 acre feet additional water.

During 1921, five duty of water tests were conducted in cooperation with the landowners and the United States Reclamation Service. These experiments were designed to assist the Reclamation Service in determining the water requirements of the various soil types and to give information on the relative efficiency of strip borders and flat checks and varying sizes of borders. It was found that the coarse sand type required an average application of 6.7 acre inches per irrigation or 6.7 acre feet per acre for the season, while the fine type only used 4.2 acre inches per irrigation or 2.4 acre feet for the year. On medium sandy land irrigated by the strip-border method introduced by the station the water requirement was 3 acre feet of water, while flat checks required 7.8 acre feet or 160 percent more water. Borders 233 feet long required 59 percent more water than borders only 90 feet

long. The supply of water is the limiting factor in the irrigation future of the state, so that economical irrigation practice is fundamental in determining the extent of development possible.

Crop Testing

The crop and variety testing work has been done with silage crops, alfalfa, pasture grasses, and a large number of miscellaneous crops.

During recent years practically 80 percent of the crop income of the Umatilla project has been derived from alfalfa, and since this is about the relative importance of the crop on the other irrigated areas along the Columbia River, the value of alfalfa variety work is significant. The varieties being tested represent the common, the hardy northern, and the southwestern types, which are the three important groups of alfalfa grown in the West. Grimm, which yielded 6.66 tons, was the highest yielding variety. Common, grown from local seed, producing 6.49 tons, was next. Farmers are advised not to purchase the widely-advertised expensive Grimm seed because it does not give much higher yields and because there is no winter killing under local conditions. If, however, they plan to raise seed crops the Grimm is recommended. Turkestan, which is a variety frequently sold in this country as imported seed of common alfalfa, was the lowest yielding variety and should also be avoided as the seed sometimes contains seed of noxious weeds.

The place of corn raised for silage is becoming more important as the type of argriculture of the irrigated lands becomes more diversified with livestock as a basis. The variety tests of corn, which have included some 70 varieties, have brought out 8 varieties which have yielded higher than the local strains commonly grown. They are Colorado giant fodder, dependable yellow dent, Boone county white, golden beauty, bloody butcher, leaming, Kaw chief, and Eureka silage.

The pasture problem on the project is one of the biggest factors in the dairy industry at the present time. Some 20 varieties of grasses and a number of mixtures of grasses have been tried. The recommended mixture with the rates of seeding per acre is orchard grass 6 pounds, Kentucky blue-grass 6, meadow fescue 4, smooth brome 4, and alsike clover 2. Sweet clover is a promising pasture crop on the sandier soils.

Hog Feeding

The 1921 hog feeding results have shown that it was more economical to grow pigs on a 2 percent ration of corn and middlings than to grow them on a self-feeder. During the finishing period, however, more economical gains were made by pigs on a self-feeder than those given a 4 percent ration.

Relation of the Station to the Farmer

Under an agreement with the office of Demonstrations on Reclamation Projects of the United States Department of Agriculture the superintendent of the station has handled the demonstration work on this project for the past two years. The work is planned to assist the farmers in their irrigation and cropping problems. During the period in which the agreement has been in effect irrigation systems for 1466

acres have been laid out on 143 farms. Approximately a third of this work has been in betterments for old systems. This work has been valuable to the farmers in saving them the expense of a surveyor and in many instances appreciable savings have been effected by improving on their plans for irrigation. Invariably the discussions during these farm visits are not limited to irrigation methods but cover a wide range of agricultural subjects.

The interest of the farmers in the station is attested by the fact that the annual field day is attended by from 500 to 1000 persons. Many of the field day visitors return for additional information, and farmers frequently come to the station to look over the work and make inquiries on their special problems. The station is often called upon for methods of disease and insect control.

The county agents are kept in close touch with the station, which gives the station an opportunity to widen its influence.

The irrigation projects along the upper Columbia River in Washington are much interested in the border method of irrigation, so the station has assisted a number of times in border demonstrations on them and delegations of their farmers come to the station to inspect the work.

HOOD RIVER BRANCH STATION

The Hood River Branch Station is maintained cooperatively by the state and Hood River county. The station staff devote a considerable part of their time to assisting orchardists of the Valley by personal visits, interviews, press articles, and correspondence. The problems under experimental study and a brief statement of results follow.

Anthracnose Control of Apple

Apple-tree Anthracnose is probably causing more actual damage to the apple orchards of Oregon than any other disease. Spraying for its control, which was worked out by the Oregon Station, was found effective while orchard holdings were rather limited and the trees small. This spray was applied after the fruit was harvested in the fall, and when so applied before extensive rains occurred, very effectively controlled the disease. Now that orchards are in heavy bearing, growers have great difficulty applying this spray before rainy weather sets in. As a result Anthracnose has greatly increased during the past few years and is causing annually a loss of many thousands of dollars to the growers of the state. Through the cooperation of the Department of Agricultural Chemistry, of the Oregon Experiment Station, the Hood River Branch Experiment Station has tested a number of materials which are being applied in the early spring and summer. Results obtained to date give much promise of bringing about not only cheaper but more effective control than has been true in the past. These new methods of control, which are being tested now will save Oregon thousands of dollars annually by keeping this disease more completely under control.

Scab Spray Investigations

Work on the control of Apple Scab is being conducted at the Hood River Station largely to determine, first, the tests of proprietary sprays

on the market; second, the strength of dilutions necessary to effect control; third (by continuing a life-history study of the disease over a period of years in connection with different spray applications), a method of spraying practice which will be more effective and economical than is now being employed.

Root Rot Investigations

A further understanding of the control of Mushroom Root Rot is a decided need of fruit growers of Oregon. A cooperative project is now under way with the Department of Plant Pathology of the Home Station at Corvallis. The most practical method of handling this trouble will probably prove to be the finding of root stocks more or less resistant to this disease. Various stocks of apple, pear, and cherries are being studied to determine their resistance. This work is not progressing as rapidly as it should because of limited time and funds.

Codling-moth Studies

Regardless of the fact that investigators have worked on the control of Codling-moth for forty years, growers are unable to get complete control without trained assistance on timing the sprays which are based upon the life-history activities of the insect. The Hood River Station issues recommendations for the timing of these applications which are used by practically all of the growers of this section. Careful study of the situation indicates that an annual saving of at least 8 percent of the crop of the district results from this work. This work alone, though not altogether experimental in nature, saves apples annually in this district worth at least $100,000.00.

Leaf-roller Investigations

This study has been carried on as a minor project during the past five years to secure further information relative to control and habits of the Leaf-roller. Our tests this year using double and triple strength Arsenate of Lead applied under a pressure of at least 325 pounds, using a gun throwing a volume of six or eight gallons a minute, destroyed many worms in both the pink and Calyx applications Regardless of the fact that many worms were killed, however, damage to the fruit, though not as severe as on unsprayed trees, is not reduced as effectively as with the oil spray, and this method can not be relied upon where the leaf-roller is serious. Arsenate of lead used in these sprays destroyed many worms and should assist in reducing the number of eggs deposited, which would give trouble the following season.

Pear Spraying Investigations

In order to determine the best methods to employ in spraying pears, a number of materials have been tested out over a period of years and as a result we are now in a position to recommend definitely to growers spraying needs in handling their various pear pests. This study has brought out the fact that certain varieties are much more susceptible to spray injury than others, for instance, the Anjou can not be sprayed with lime-sulfur after the Delayed Dormant spray

without causing severe russeting. A complete report on this work will be available in the near future.

Fertilizers for Orchards in Hood River Valley

Experiments have been under way for eight years to determine the best commercial fertilizer for bearing apple trees. There are a number of factors which have a direct bearing upon practical results. Average yields per tree constitute the most important factor. Economical orcharding requires maximum tonnage consistent with merchantable quality. Oregon specializes in varieties characteristically shy bearers. This is due principally to the fact that in many orchards alternate bearing has become more or less a fixed habit. The aim in using fertilizer is to induce ample new growth each year sufficient to cause the development of many new fruit-spurs. The use of nitrate of soda, sulfate of ammonia, and nitrogen (air manufactured), at the rate of from three to five pounds per tree have been found satisfactory.

The need of a complete fertilizer containing potash and phosphoric acid in addition to nitrogen has also been under study. Results thus far do not indicate practical results from such fertilizer as measured in yields and quality. These observations conform to results in the Wenatchee Valley, Washington, where similar tests have been made. Tests are being conducted in orchards on silt and sandy loams.

Observations during the past three years also favor the use of nitrogen on bearing pear trees located on the so-called "Red Shot" soils in the Upper Valley. While alfalfa has been establishing itself in a thirteen-year-old Anjou orchard, the trees have responded better in growth, color of foliage, and yields from annual early spring applications of nitrate of soda at the rate of three pounds per tree. What the future requirements will be when cover crops are more fully established and cultivation employed, will require additional study. It is reasonable to expect that heavy annual applications of commercial fertilizer will not be as essential under improved soil conditions. It is unlikely that any set formulae as a practice will be arrived at. Best results require a careful balance between shade crops, fertilizers, irrigation, crop prospects, pruning, and related factors.

Shade Crop Studies

The most satisfactory manner of handling alfalfa in the orchard is also under study. Tests are under way to demonstrate the relative merits of removing hay in one or two cuttings, compared with allowing the cut hay to remain in the form of a mulch, or remaining uncut. Average yields per tree for the last three years do not favor any particular plan. Fruit from trees growing in the uncut alfalfa was larger in 1920, but this was not strikingly so in 1921.

Strawberry Fertilizers

Nitrogen has also been a limiting factor where strawberries are grown. As much as 440 pounds nitrate of soda per acre has been applied in early spring. On "Red Shot" soils, yields have been increased materially.

The use of "complete" fertilizers has received considerable attention. These are used in different amounts and combinations and applied either in early spring or midsummer or at both times in whole or one-half portions. From the use of 220 pounds nitrate, 300 pounds superphosphate, and 72 pounds of sulfate of potash, one half of which was applied in midsummer and the remainder in early spring, yields were increased 72 percent in 1921. It appears that heavy applications of nitrogen and comparatively low applications of potash produce largest yields. Where potash is used, small seedy berries result, but where excessive nitrogen is employed, berries although large and giving heavy tonnage, are inclined to be soft, especially during a short, hot ripening season. Incidentally, some work has been done to determine the best time to top strawberry plants. Tests include topping right after harvesting, topping two and four weeks later, and no topping. Yields and sizes of berries favor early topping.

Potato Fertilizers

The use of nitrate of soda, sulfate of ammonia, and superphosphate on potatoes has proved economical. The former has been used in as large quantities as 500 pounds per acre, and superphosphate 1000 pounds. Last year yields were increased from 131 to 213 sacks per acre or 62 percent.

Variety Tests

Since 1919, 73 varieties of strawberries have been tested for quality, growing habits, adaptability, and yields. The Clark under local conditions is best because especially attractive and a good shipper. Other varieties worthy of note are Tebla, Ettersburg 121 and 450 Marshall and Belt.

Pruning Experiments

These experiments apply to apples in bearing and pears both bearing and non-bearing. The aim is to correlate this practice with that of soil management. The development of new growth and fruit-spur formation, together with blossoming habits and yields, are receiving critical study. Heavy pruning together with heavy fertilization appears to be at least a temporary plan with Anjou pears.

Factors Influencing the Bearing Habit of the D'Anjou Pear

The Anjou pear throughout the state is characteristically a shy bearer except under certain unknown conditions when it produces heavily. A large number of tests are being carried on to determine this irregular bearing habit. These include girdling, bridge grafting, spur pruning, heading, thinning, artificial bending of branches, and soil management. Pollination may also be a factor.

Time of Picking Fruit

Tests have been under way to determine the best time to pick Spitzenburgs, Newtowns, and Anjou pears. Studies are made indicating development of fruit both on the tree and in cold storage. Newtowns picked late in October 1921 developed "fruit pit" and broke

down later in storage. Fruit picked during early October held up well but did not attain such large size. October 15 usually may be considered most practical for this variety. Spitzenburgs picked October 6 possessed better keeping quality and flavor than those picked October 18.

Anjou pears develop and attain best size and quality when picked as late as October 1 to 8. On an average this fruit increased from 10/16 to 13/16 inches in circumference during the last month of growth. Shrinkage in storage was also much less than that of early-picked fruit. The sugar content after six months cold storage was noticeably greater with late-picked fruit. The appearance was also better in that the greenish color was replaced by a soft golden yellow.

Two or Three Outstanding Accomplishments of the Hood River Station

There are two or three outstanding accomplishments which feature the investigational work of the Hood River Station since its establishment ten years ago. Probably the most important of these, and that which has been productive of the greatest returns to growers of the Hood River Valley and the state as a whole, has been obtained from a study of the problem of Fertility and Soil Management. It can be said that the application of these findings has increased production not only in Hood River Valley but in practically all other apple sections of the state fully 40 percent.

A study of the main factors in orchard management has been made under Hood River conditions. These have been correlated and published in Station Bulletin 181.

Our understanding of Apple Scab control based on a number of years' work, enables us to give recommendations which will completely control this disease under most adverse conditions, provided growers follow recommendations as given by the Station. Scab has not been of much importance during the past two or three years, but when conditions favorable for infection occur again, the information now available will be worth large sums of money to the fruit grower of not only Hood River, but the state at large.

Service

The Hood River Station is maintained in part by Hood River county, and the county has no County Agricultural Agent. Naturally therefore there are many calls upon the Station for assistance and many opportunities for giving assistance. Records kept from May 20 to June 20, 1922, for example, show that the Station received 240 telephone calls, 233 office visits, 86 letters calling for information and advice. This is approximately an average for the six months of growing and harvesting crops.

SHERMAN COUNTY BRANCH STATION, MORO

That yield per acre is the dominating factor in determining farm profit has been clearly shown in all cost-of-production studies. The purpose of the experiments at the Branch Station at Moro is primarily to determine how crop production can be economically increased. These experiments are conducted along four general lines: (1) varietal trials to determine the highest-yielding farm crops for the Co-

lumbia Basin dry lands, and the best rates and dates of sowing them; (2) cereal breeding investigations to isolate by selection or to produce by hydridization higher-yielding grain varieties; (3) tillage experiments to ascertain the most economical method of handling the soil to obtain high yields, and (4) crop rotation experiments to find out what crops can be partly or entirely substituted for summer fallow and the best method of growing these crops in rotations to obtain profitable yields and still maintain soil fertility.

Varietal Experiments

The testing of grain varieties for yield is the oldest kind of experimental work in this country. Yet it is a type of Station work that will continue to be important because new varieties of grain are constantly being produced. Unless some public agency like the Experiment Station does this work individual farmers or communities will be compelled to do it at a much heavier expense with less accurate results.

The great economic value of this work can be readily understood when it is realized that a one-bushel increase in the acre yield of wheat in the eighteen counties of Oregon east of the Cascades would add more than 800,000 bushels annually to the total annual wheat production of the state. In many of these counties, the acre-yield of wheat has been already actually increased from three to five bushels per acre through the introduction by the Moro Station of higher-yielding varieties and the adoption by farmers of improved tillage methods discovered by this Station.

In order to find out what grain varieties already in existence might prove valuable for Eastern Oregon, practically all of the commercial wheat varieties of the United States, as well as those of India and Australia, have been grown at Moro.

Winter Wheat. Of the winter wheats, several strains of the Turkey group have been found to be superior in yield to the locally grown Turkey variety. One of these, Kharkov, has been distributed from the Branch Station and is now being widely grown in the Columbia Basin of Eastern Oregon.

The careful trials at the Branch Station show that this variety has exceeded the yield of the local Turkey wheat 8 percent. There are usually about 6,500,000 bushels of wheat annually produced in the four Columbia Basin counties of Wasco, Sherman, Gilliam, Morrow. More than two-thirds of this wheat is Turkey or some strain of Turkey, and about one-third of this or 2,500,000 bushels in 1921 was Kharkov wheat. If it is assumed that this variety yielded only 5 percent more than the local Turkey, this would mean a net increase to the farmers of these counties of more than 129,000 bushels of wheat because of growing the Kharkov variety distributed from the Moro Station.

Spring Wheat. In the Australian wheat varieties there have been found two especially valuable spring wheats for the Pacific Northwest. These are Federation and Hard Federation. In a careful four-year trial, these varieties have exceeded the yield of Early Baart more

than 20 percent. Prior to this time, the Early Baart variety had been found to be the highest-yielding dry-land wheat, and largely because of the Station's recommendations had supplanted Pacific Bluestem spring wheat, the commonly grown spring wheat in the Columbia Basin of Oregon. A ten percent increase in the spring wheat yield of Eastern Oregon would exceed 297,000 bushels annually.

Trials made by farmers in 1921 indicate that both the Hard Federation and Federation varieties will be adapted to practically all of Eastern Oregon. The Federation variety has also proved to be an exceptionally high yielding variety under irrigation. Both these varieties have been widely distributed to farmers in every Eastern Oregon county, and the results obtained by these farmers strongly indicate that these superior wheats will soon be important commercial varieties in Eastern Oregon.

Other Cereals. Varietal testing and pure-line selection work have also been conducted at Moro with spring barley and spring oats. The Mariout variety has been found to be a higher-yielding variety than the commonly grown barley, and selections have been made from Sixty-Day and No. 357 oats which have outyielded the common local variety from 9 to 10 percent during a nine-year period.

Rates and Dates of Sowing Wheat

Careful experiments have been conducted at the Moro Station to determine the best rate and date of sowing winter and spring wheats. In these investigations, it has been shown that early sowing of winter wheat on the average will produce from eight to ten bushels per acre more than late sowing. This information has proved of great value to farmers, most of whom are now sowing winter wheat earlier than formerly. The trials at the Moro Station have proved that spring wheat should be sown as early as possible in the spring to obtain maximum yields.

The most profitable rate of sowing Turkey winter wheat, the most commonly grown variety in Eastern Oregon, has been found to be five pecks per acre. The most profitable rate for sowing Pacific Bluestem spring wheat was also five pecks per acre.

Cereal Breeding

To produce high-yielding grain varieties, two general methods are employed, pure-line selection and hybridization. In the pure-line selection method, heads are selected from desirable plants and the seed from each planted in a short row. The resulting grain from each row is then threshed and planted in longer rows, the process usually being repeated several times. Each pure-line, as the progeny from a single head is called, is kept under observation in rows for several years and the seed of the most promising ones increased and placed in the regular varietal trials. The average yields of the varieties or selections are compared for several years and the most desirable ones increased in larger fields and distributed to farmers for further trial.

The hybridization work consists of producing new varieties by artificial crossing. This is not a difficult procedure though many

years of careful selecton are necessary before the hybrids become fixed and breed true to type. After from four to six years' work of selection, the promising types are increased and planted in rod or two-rod rows, replicated, and thus tested for yield in the plant nursery. From this stage, the procedure is the same as for the pure-line selections, the promising hybrids being increased and placed in the regular varietal trial and the high-yielding or desirable ones distributed to farmers.

Notable progress has been made in producing high-yielding wheat varieties by both pure-line and hybridization methods of breeding. Marquis wheat is a hybrid produced by the Central Experimental Farm at Ottawa, Canada. The Washington Station has produced several high-yielding wheat varieties through hybridization. One of the best examples of wheat improvement through pure-line selection was the production of Kanred wheat by the Kansas Experiment Station.

Pure-line selection work with wheat has been carried on at the Moro Station during the past six years. By this method some high-yielding types have been selected from Kharkov wheat and Sixty-Day oats, and some very valuable smut-immune and smut-resistant wheats have been produced from several winter wheat varieties.

The main purposes of the hybridization work at Moro have been (1) to produce a high-yielding, beardless variety of winter wheat similar to the hard winter Crimean of Turkey group; (2) to produce a white-kerneled, hardy winter wheat of the type of Federation and Hard Federation spring wheats; (3) to produce a high-yielding smut-resistant winter and spring wheat variety. Hundreds of hybrid varieties are now under observation in the cereal breeding nursery, and it is confidently believed that some valuable varieties, especially from the standpoint of disease-resistance as well as yield will be found among these hybrids.

Tillage Experiments

Careful experiments have been carried on at the Moro Station for a nine-year period to determine the most profitable method of soil cultivation for growing wheat after summer fallow. These experiments have proved that early plowing for summer fallow increased wheat yields three to six bushels per acre. The nine-year average yield of Turkey wheat after summer fallow plowed April 1 was 6.2 bushels per acre more than wheat after summer fallow plowed June 1 and 2.3 bushels per acre more than wheat after summer fallow plowed May 1. It has been determined that these results apply to practically all of Eastern Oregon, where in 1920 there were 667,800 acres of winter wheat grown. The value of early plowing has been emphasized both in Experiment Station bulletins and by Extension Service workers, and it is believed that there has been at least a three-bushel increase in the acre yield of wheat in all Eastern Oregon counties because of this discovery. A three-bushel increase on only one-half of the acreage of wheat in Eastern Oregon would aggregate more than a million bushels, and it is certain that more than one-half of the farmers in this region are plowing their ground from five to six weeks earlier than they did seven or eight years ago before the results of these experiments were available.

These experiments have also shown that spring disking of stubble ground as a preparation for fallow does not pay; that deep plowing only slightly affects the yields of wheat after fallow; that the subsurface packer does not increase wheat yields; that harrowing winter wheat in the spring usually does not pay. These results have proved to be of much importance to the economical production of wheat on the dry lands of Oregon.

Rotation Experiments

Ten years' results have been obtained on several rotation experiments in order to anticipate future problems that may arise in regard to maintenance of soil fertility in Eastern Oregon wheat lands. The purposes of these rotation experiments are (1) to determine what crops, if any, can be partly or entirely substituted for summer fallow, and (2) to find out what will be the cheapest and most practical methods of maintaining the fertility of Eastern Oregon soils that are now being slowly depleted by continuous grain growing.

Much valuable data already have been obtained on these vital questions from the thirty crop rotations carried on at the Moro Station. In these experiments, the different grains are grown in rotations with corn, peas, potatoes, and various leguminous and non-leguminous crops used as green manure. This Station has definitely determined that, when utilized for stock feed, field peas can be made a profitable crop on most Eastern Oregon soils. This discovery may in the future prove to be of much economic importance, as it provides one remedy for renewing worn-out soils that have become deficient in nitrogen on account of continuous grain growing.

Soil Moisture and Nitrate Investigations

For the past three years investigations have been carried on at the Moro Station, in connection with the tillage and rotation experiments, to determine just what effect different soil-tillage and crop-rotation methods have on the accumulation in the soil of nitrate-nitrogen, the most important plant food, and on the absorption and retention of soil moisture. It is hoped that these investigations will result in a better understanding of why certain soil tillage and cropping methods influence crop yields, thus laying the foundation for new cropping systems that will return profitable yields and still permanently maintain the fertility of the soil.

SOUTHERN OREGON BRANCH STATION, TALENT

Blight Resistance

The chief work of this Station is devoted to the study of blight resistance in pears. Pear Blight is the greatest hazard in pear growing, and the losses from this disease are enormous. In many regions it has completely wiped out the industry. In practically all pear districts the losses sustained from this disease are heavy. In Southern Oregon it annually takes a heavy toll and at times the industry has been threatened; thousands of trees have been destroyed, and in some cases entire orchards have been dug up because the cost of controlling

the disease has been too great. No satisfactory remedy has been found. The only remedy now known is to cut out and destroy all the affected portions and blighted trees, in order to keep the blight from spreading and destroying the entire orchard.

The only solution of the problem appears to be in finding or producing stocks and varieties which will naturally resist the disease. For many years horticulturists have been looking for such resistant varieties of pears, but heretofore none have been found. This is due to the fact that all of the varieties so far grown in this country are highly susceptible.

It was apparent from this that resistant species and varieties throughout the world must be extremely rare, if they existed at all. Since pear blight was not known in any other country than America, and since all the known pears are natives of other countries, the writer realized that the only hope was in collecting all the known wild species of pears, and as many cultivated varieties as possible, bringing them to this country, and testing them for blight resistance and susceptibility. For this reason this Station established the most complete collection of pears in the world, including all the known species and hundreds of varieties. This collection includes all the varieties cultivated in America, the wild species from Europe, Asia, and Africa, and a large collection of cultivated varieties from Europe, China, and Japan. These have been thoroughly tested by inoculating them thoroughly with pear-blight germs.

It has been found that nearly all of them are susceptible, but fortunately a very small percentage of resistant types have been found.

These are the first immune pears ever recorded in America. Of these immune types some appear extremely promising as blight-resistant stocks onto which to top-graft our commercial varieties. Since pear blight annually causes losses amounting to millions of dollars, by destroying the root system, trunk, or framework of the trees, the great importance of finding and planting trees with a resistant root system, trunk, and framework can hardly be overestimated. All the newer plantings of pear orchards in Southern Oregon consist of such resistant trees, introduced and recommended by this Station.

These resistant types are now being propagated as rapidly as possible. At the present time they are being tested for vigor, suitability for wet and dry soils, heavy and light soils, resistance to insects, resistance to extreme heat in summer and cold in winter, and especially to determine which will make the most satisfactory union and growth with our commercial varieties when these are grafted onto them. For this purpose test orchards are being planted at the Station and in commercial orchards on various types of soil throughout the Valley.

We have found that the seedlings of even the immune varieties will vary greatly in their resistance to blight, a small percentage proving immune, while a large proportion will blight more or less, and many of them seriously. This is unfortunate, and the only way to reproduce the resistance stocks, true to type, is to propagate them from either branch or root cuttings. This can be done only where soil and climatic conditions are suitable. For this reason cuttings have been sent for propagation to several nurseries in regions where

the climatic conditions are favorable for such propagation. The results will be awaited with great interest.

Disinfectants for Blight Work

The method of combating pear blight practiced at the present time consists in cutting out all the affected portions of the tree and thoroughly disinfecting the wounds thus made and the tools used in this work. As indicated in my last report, we found at this Station that the bichloride of mercury formerly used for this purpose by all pear growers was worthless for disinfecting the wounds of the trees. This disinfectant, however, proved effective on the metal tools used in cutting out the blight. For the wounds a great many disinfectants were tried, nearly all of which proved worthless. One of these, cyanide of mercury, proved absolutely effective on the wounds, but not always effective on the tools. A combination of these two was then tried, and this proved effective on both wounds and tools. This disinfectant is now used by practically every pear grower in Southern Oregon and California. Every grower reports far more satisfactory blight control since using this new disinfectant than formerly.

New Pear Varieties

The extensive variety collection of pears at this Station contains many of the finer European varieties never before tested in this country. While most of these that have so far fruited have not proved superior or even equal to our best standard varieties, a number of them appear especially promising. One of these varieties, Dr. Jules Guyot, is similar to Bartlett, but a week earlier. Two varieties, namely, Besi de Beugny and Baronne de Mello, are late russet varieties, similar to Winter Nelis, but slightly larger and more attractive, and the Besi de Beugny is of far better quality. Many other varieties are fruiting for the first time this year, and it is possible that some of these may prove very valuable.

Pear Breeding

Pear breeding work was started at this Station during the spring of 1921, and this was very much enlarged during the past spring. The primary object is to produce desirable new varieties of pears which will be resistant to blight. In this work we are crossing the best American varieties like Bosc and Anjou with the best blight-immune Chinese varieties, the object being to combine in one tree the large size and fine flavor of the American varieties with the blight-resistant characteristic of the Chinese varieties. If only one such desirable tree can be obtained, it can then be multiplied rapidly by budding or grafting. This work must be done on a large scale and final results cannot be expected for a number of years. With the valuable Chinese varieties now available for this work for the first time, it appears as though valuable results can be expected. In fact, this is really the first time that entirely satisfactory material has been available for breeding blight-resistant varieties of pears. The hybrids which were made in 1921 were planted during the past spring and the young seedlings are now making a very satisfactory growth.

Fertilizers for Fruit Trees

The fertilizer work on apples, pears, and peaches, which was started several years ago, is being continued. The results during the past two years have been similar to those obtained during previous years. The potash and phosphoric acid have had no effect on the trees or the yields up to the present time. The nitrogen, in the form of nitrate of soda, dried blood, and sulfate of ammonia, has had a very marked influence on the growth and vigor of the trees, and the size and amount of fruit. This has been particularly true of apples on pumice soil, and with peaches on granite soil.

Frost Fighting or Orchard Heating

Killing frosts are experienced on the floor of the Valley during the blooming season of pears almost every season. The only feasible way to obtain full crops of pears under such conditions is to practice orchard heating. Orchard heating has been practiced more or less in this Valley during the past fifteen years, and the interest manifested in this matter is now greater than ever before. The heat is obtained by burning the cheaper grades of oil in smudge pots or orchard heaters.

Various oils have been used by the growers, and during the past winter four oil companies attempted to sell their particular oils to the growers. Since these oils show considerable variation, the writer made a thorough comparative test of all of them, to determine the burning time per gallon and the amount of heat given off by all of them. The various oils showed far greater differences in this respect than any one could have predicted. In the old-style smudge pots the burning time varied from three hours to four hours and thirty minutes. In the new Scheu heaters, the burning time varied from five hours and forty-three minutes to six hours and fifty minutes. The importance of determining this fact can be appreciated in a region where many car-loads of smudge oils are used per year.

Another test was to determine the amount of residue, consisting chiefly of asphaltum, left unconsumed in the smudge pots by the various oils. This varied from nothing to 122 grams per gallon of oil. This sediment, especially the asphaltum, is very objectionable, as it reduces the capacity of the pot, and it is very difficult to remove from the pot at the close of the frost season.

It was also determined that the new Scheu heater consumes the heavier oils much more completely than do the old smudge pots. No asphaltum remained in the Scheu pots, the sediment consisting only of loose scale and clinkers which could be easily dumped out of the pots.

Preparations were made for an exhaustive comparative test of the old-style smudge pots with the new Scheu orchard heaters during heavy frosts under field conditions. Since there were no injurious frosts at the Station this year, during the blooming season, this test could not be made. All of the equipment has been installed, however, and the tests can undoubtedly be made next year.

Pollination of Pears

The Comice and Anjou pears are notably shy bearers in most of the orchards of Southern Oregon. The writer believes that this is primarily due to lack of proper pollination. There appears to be no satisfactory pollinator for these two varieties among the commercial varieties of pears generally grown in the orchards of this Valley. It is calculated that the loss from the poor set of Anjou and Comice pears in this Valley annually amounts to at least $100,000.00.

Heretofore it has been supposed that frost and chilling weather during the blooming season was responsible for the usual heavy drop of the Anjous. This year we proved beyond all doubt, at the Experiment Station, that the Anjous will not set well, even when the weather conditions are perfect. One tree was perfectly protected with a large shed and an oil stove on all nights when even light frosts occurred. The set of fruit on this tree is no larger than on the unprotected trees.

It was also demonstrated that the Bartlett is not a good pollinizer for the Anjou. In our orchard we have two rows of Anjous and two rows of Bartletts, side by side, which were in bloom during the same time this year, and numerous bees were very active during the blooming season, carrying pollen from one variety to the other; nevertheless, the crop is very small on these Anjou trees, as it has always been in past years. The indications are that the Anjou is intersterile with at least some of our varieties and possibly with most of our commercial varieties.

We expect to carry on extensive pollination work with the Anjou and Comice next spring, with the hope of finding a satisfactory pollinizer for these varieties.

Pollination of Cherries

Previous to this season our Bing, Royal Anne, and Lambert cherry trees have produced very poor crops. Many complaints of unproductive trees of these varieties have come to this Station from numerous places. We have found that these varieties are self-sterile and intersterile in this Valley.

During the blooming season of the past spring branches of Black Tartarian and Black Republican cherries, covered with blossoms, were placed near these trees. The pollen from these was carried by bees to the blossoms of the Bing, Lambert, and Royal Anne. As a result these trees are producing a very heavy crop this year. We are budding a few of the branches of our trees with Black Republican, and also advising our cherry growers to do this wherever their trees are now unproductive. We are also advising those who are planting new cherry orchards to plant at least one Black Republican or one Black Tartarian for every twenty trees of the usual commercial varieties planted here.

Improved French Prune

During the year 1914 the writer obtained propagating wood from an exceptional tree of French Prune in California which, according to reports, bore unusually large fruits. The scions have borne during

the past three seasons, and the fruit is twice as large as that of the standard French prunes. Since the only objection to the French prune is its comparatively small size, the increased size of this new French prune will prove of very great value. Some of our prune growers are already top-working their trees with this improved new strain.

Orchard Cover Crops

The orchard soils of Southern Oregon are sorely in need of humus; and the most satisfactory way to obtain this is by growing leguminous cover crops during the winter months. The Oregon vetch is the only one which has heretofore been available for this purpose, and this has usually proved unsatisfactory. The plants winter kill and a large percentage are killed by the Wilt disease. As a result of this unsatisfactory experience orchardists have practically given up the growing of cover crops.

This Station for several years has been testing a number of the newer vetches, introduced by the Station at Corvallis. The woolly podded, the Hungarian, and the Hairy vetches—especially the first two—are giving excellent results on our heavy soils. These will be introduced into our orchards at once and their use strongly recommended.

Advisory Work

A very large portion of the Superintendent's time is devoted to advisory work. A large percentage of the ranchers in this Valley, and particularly the fruit growers, have come to the Valley during the past ten or twelve years. They have come from all walks of life and include many business and professional men from the cities and people who have had little or no experience in agricultural matters. For this reason these people need a great deal of help and advice, often on general matters pertaining to farming with which the experienced farmer is already familiar. Furthermore, fruit growing is really a scientific profession and new questions are constantly arising. It naturally follows that the Superintendent must answer many inquiries by letter and telephone. Numerous visits to the orchards must be made throughout the year, to give expert advice on various subjects. Many ranchers from the Valley and from other portions of Oregon and even from adjoining states, visit the Station during the year to obtain advice regarding agricultural and horticultural problems and to see the work that is being conducted by the Station.

Soil and seed samples, diseased plant specimens, insects, varieties of fruit, fruit stocks, grasses, and plants of various kinds are brought to the Station for identification.

A great deal of spraying is necessary in producing a successful crop of fruit. A variety of sprays are used and these must be applied at the proper time. Many inquiries regarding these matters are constantly coming to the Station.

Outstanding Accomplishments

The outstanding accomplishments of this Station are:

1. Determining that sulfur is a necessary and very valuable fertilizer for alfalfa and other legumes in Southern Oregon.

2. The introduction, testing, and finding of blight-immune stocks and varieties of pears.
3. Determining the fact that the old standard bichloride of mercury disinfectant is worthless on the wounds of pear trees when used in blight control work.
4. That cyanide of mercury is a thoroughly effective disinfectant for the wounds of pear trees in blight-control work.
5. That nitrogen is the only fertilizer needed at present on the soils of Southern Oregon in the production of maximum crops of peaches, pears, and apples.

EASTERN OREGON BRANCH EXPERIMENT STATION, UNION

Investigations with Livestock

The work of the Eastern Oregon Experiment Station with livestock for the biennium ending June 30, 1922, is largely a continuation of the work outlined in the past report.

Fattening Steers. Several tests with shelter for fattening steers were concluded and also two tests with warm water. These tests are reported in detail in Bulletin 183, "Shelter and Warm Water for Fattening Steers". This bulletin is summarized as follows:

Fattening steers, fed and sheltered in the barn and having access to a lot for excerise, consumed the same amount of feed and made very little more gains than those fed in the open.

Fattening calves, given access to a shelter shed, consumed the same amount of feed and made the same gains as did those without the shed.

Fattening steers, given water warmed to an average of 43 degrees, consumed the same amount of feed and made the same gains as did those which received cold water.

Additional work has been done with the use of grain in various amounts for finishing silage-fed steers with a view of lessening the shrink en route to market and of increasing the dressing percentage. In this one test it was found that the dressing percentage depended entirely upon condition. Silage-fed steers were fatter than hay-fed steers and dressed more. Grain-fed steers were fatter than those not having had grain and the more the grain the fatter they were and the higher the dressing percentage. The grain just about paid for itself. Contrary to expectations the silage-fed lots shrank less en route to market than those fed hay alone or than those receiving grain. This work has not been published in bulletin form and will have to be repeated before positive conclusions can be drawn.

Growing Cattle. The tests mentioned in the last report have been finished and the results published in Station Bulletin 182. This bulletin may be summarized as follows:

Methods of wintering growing steers not only determine the gains made during that period, but also influence in a large degree the gains made during the grazing season, as well as the age, final weight, and quality of the cattle when ready for market.

Steers that have been wintered lightly as calves and yearlings, do not weigh as much when finished as do those that made larger gains during the winter feeding period.

Fat calves or yearlings from the winter feed lots made less gains than thinner cattle during the growing season.

Growing steers making large gains during the winter, lose practically one-half of this advantage gained over the lighter fed steers, owing to the small gains made during the grazing season.

Young growing steers should hold their own during the winter, but large gains during the winter feeding period are neither necessary nor desirable unless they can be made economically.

Gains made on grass are always cheaper than those made on winter feeds, hence growing steers should be kept on grass for the longest possible time during the grazing season.

The feeding of grain is necessary in the production of baby beef, but is not recommended with growing steers that are to be turned out on grass.

In sections where plenty of range is available for grazing purposes marketing steers as baby beef is less profitable than marketing them as two- or three-year-olds.

Alfalfa hay is the standard ration for wintering cattle and the one with which all other rations are compared.

Silage alone can be used as a winter ration, but better results are obtained when silage is fed in connection with some protein supplement, such as alfalfa hay or cottonseed cake.

Straw supplemented with cottonseed cake, with or without silage, or with silage alone, can be used for wintering purposes, in cases of emergency, with economic results.

A fourth test is under way and is now in its second year.

Fattening Lambs. The work with fattening lambs has been continued especially with reference to the use of silage. This work has been published as Station Bulletin 184 and is summarized as follows:

Alfalfa hay and barley constitute a very satisfactory ration for fattening lambs.

Silage added to a ration of alfalfa hay and barley does not increase the gains materially, but may be used in connection with fattening lambs, provided it can be produced economically.

In terms of amounts of feed replaced per 100 pounds gain where alfalfa hay is valued at $8.00 and barley at $25.00 per ton, peas-and-bald-barley silage has a value of $5.05 and sunflower silage $3.96 per ton for fattening lambs.

Lambs fattened on alfalfa hay and barley, with and without silage, made very satisfactory gains, and there was no apparent difference in the final condition of the finished lambs.

This work was repeated during the winter of 1921, and while the results are as yet unpublished they confirm in a very great measure the work reported above in Bulletin 184.

Wintering Ewes. Two tests were completed with wintering ewes on corn, peas, and barley, and sunflower silages and on alfalfa hay alone. The silages were fed at the rate of one pound per head per day in addition to all the alfalfa the ewes would eat. All lots wintered in excellent shape and all rations proved satisfactory.

Fattening Pigs. One test was completed with fattening pigs on various pasture crops, winter rye, winter wheat, peas and oats, peas, and alfalfa. The alfalfa-pasture lots made the most economical gains, although slightly less gains than the rye and the wheat lots. The peas made the next most economical gains. The rye, wheat, and the peas-and-oats lots were less satisfactory. There was a good deal of waste in all of the cereal pastures.

Growing and Fattening. The value of a forage crop in connection with the growing and fattening of hogs is well known. While alfalfa is the crop which is usually used for this purpose, it was considered well to test this crop in comparison with other leguminous and non-leguminous forage crops.

Fifty hogs were used in the experiment. Those that had access to winter rye, planted in the spring, in conjunction with rolled barley in a self-feeder, made the most gain, with those in the winter wheat lot a close second. The hogs in the remaining lots which were seeded to peas and oats, peas, and alfalfa, respectively, made slightly less gains. From the standpoint of economical gains, however, the alfalfa lot apparently has a slight advantage.

Wintering Brood Sows. Brood sows that are to farrow pigs in the spring should have some grain during the winter months. Fleshy-natured sows can be carried through the winter in good condition if given all they will eat twice daily of a mixture of 1 pound of rolled barley and 2 pounds of chopped alfalfa. Medium fleshy sows will do well on a mixture of 2 pounds of rolled barley and 2 pounds of chopped alfalfa. Immatured sows need a mixture of 3 pounds rolled barley to 2 pounds chopped alfalfa.

It is also found advisable to add some tankage to the ration beginning a week or ten days prior to farrowing.

FIELD CROPS

Forage Crops. Production tests under field conditions are conducted with Grimm alfalfa, peas and barley, and common alfalfa as hay crops. Likewise tests are made with peas and barley, corn, and sunflowers as silage crops. Sunflowers yield as high as 20 tons per acre, peas and barley yield from 6 to 8, and corn from 8 to 10 tons per acre.

Records are kept on the cost of growing and harvesting each crop. A fertilizer and rotation experiment containing 52 tenth-acre plots is under way, covering such crops as alfalfa, peas and barley, wheat and corn.

Cereals. Varietal tests under both plot and field conditions are conducted with wheat, oats, and barley. The breeding and selection of desirable types of wheat, barley, and rye are in progress. Several new beardless barleys will be ready for limited distributions the coming season.

SERVICE

A "Feeders Day" is held at the Station during the winter feeding period in order that stockmen may have the opportunity of seeing the

livestock in their respective yards, and of noting results obtained by the feeding of the various rations.

A "Field Day," usually in connection with the annual meeting of the Grange, is held at the Experiment Station each year during the growing season. This affords opportunity for the farmers to view the experimental tests, noting the difference in appearance and apparent yields of the various crops.

The service of the Station also includes:

The sale and distribution of improved varieties of seed grain.

The tabulation and distribution of experimental data covering feeding experiments.

The preparation of newspaper articles, and replying to numerous inquiries pertaining to agricultural matters.